Materials

in Design Engineering

COMPARISONS OF MATERIALS
IRONS & STEELS
NONFERROUS METALS
PLASTICS & RUBBER
OTHER NONMETALLICS
FINISHES & COATINGS
COMPOSITE MATERIALS
FORMS & SHAPES OF MATERIALS
JOINING & FASTENING

SUPPLIERS OF MATERIALS
ADDRESSES OF SUPPLIERS

Materials
in Design Engineering

MID-OCTOBER, 1961

Materials Selector Issue

This issue of MATERIALS IN DESIGN ENGINEERING features a summary of the latest available data on engineering materials, forms, finishes, and joining and fastening methods. The issue consists of two major sections: a Data Section and a Directory Section.

The Data Section consists of nine subsections and contains: (1) extensive data on physical, mechanical, chemical, electrical, thermal, and fabricating properties of virtually all important engineering materials, including finishes and coatings; (2) an indication of test conditions; (3) listings of available forms and typical uses; (4) descriptions of forming methods and the types of parts that can be produced; and (5) information on methods by which materials can be joined. Most information is given in tabular form for easy comparison.

The Directory Section contains the names and addresses of leading suppliers of engineering materials, finishes, forms and shapes. A full explanation of the organization and use of the Directory Section is given on page 472.

Contents of the entire issue are listed on these two pages; in addition, a more detailed contents page appears at the beginning of each subsection, and a comprehensive, cross-referenced index appears on pages 2 to 6. Like all issues of M/DE, this one contains an extensive listing of helpful suppliers' bulletins; these precede each data subsection. Pertinent advertisements can be found at the end of each section.

Indexes, etc.

Suppliers' Literature

MID-OCTOBER, 1961
VOL. 54, NO. 5

Materials
in Design Engineering®

FORMERLY MATERIALS & METHODS

APPLICATION OF METALS, NONMETALLICS, FORMS, FINISHES

MATERIALS SELECTOR ISSUE

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DATA SECTION

DIRECTORY SECTION

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How to Use the Materials Selector Issue

Naturally, you can use this issue in many different ways, depending upon the nature of your own materials problem. However, this issue is called the Materials Selector Issue because it is designed to help you systematically narrow your choice of materials, forms and finishes to meet a specific problem. Here is a logical procedure:

1. Look up the critical properties in **Comparisons of Materials** to see which materials warrant further investigation. This section consists of tables comparing the important engineering materials with respect to a particular property (e.g., tensile strength, ductility, thermal expansion, etc.). Materials are ranked in descending order of the highest value of their typical properties (the lowest typical value is also given). In some cases, the form, temper, heat treatment, or other condition of the material is given, particularly where such conditions markedly affect the value. A comparison price chart is also included. When you have found several materials that fulfill initial requirements, turn to the **Index to Data** to find the pages in the Data Section on which complete data are given for each of the materials selected.

2. Now reduce further the number of potentially suitable materials by turning to the appropriate portions of the **Data Section** and comparing promising materials as to other significant properties, available forms, typical uses, finishing methods, joining methods, and fabricating and forming methods.

3. Next, look up the promising materials and forms in the **Directory Section** to obtain the names and addresses of suppliers in your area.

4. Get further information on properties, availability and cost of materials and forms by a) consulting the **Suppliers' Literature** pages at the

beginning of each subsection and circling key numbers of promising bulletins on one of the eight free post cards (pp 553-560); and b) consulting the **Advertisements** placed at the end of each section and circling their key numbers on the free post cards. Names of advertisers are bold faced in the Directory Section and the pages on which their advertisements appear are indicated.

What the Data Mean

The data presented in this issue have a specific and limited purpose. Space does not permit a complete description of the materials and test conditions to which the data apply; hence, the data cannot be used directly for final designs. They are intended solely to aid in the important job of materials selection—that is, to help narrow the choice of materials, forms and processes for a specific job. In developing final designs, contact individual suppliers for more detailed data.

Tabular data in this issue generally represent average test results obtained from many different sources and suppliers. Although the values may have been obtained from standard specified tests, in no case do the values represent absolute minimum or maximum specified limits. Where a range of values is given, it may indicate either the normal variation encountered in that particular test or the differences attributable to variations in the composition, temper, heat treatment, form, or other condition of the material. Where a value or range applies only to a particular condition of the material, the condition is stated.

Available forms listed in these sections are the most important forms that are readily available commercially. Uses listed in these sections are only typical and are not intended to be exhaustive.

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Use this index to *keep up to date* by looking up the advertisements on those materials in which you are most interested, on pages listed below. *Get more information* on advertised products by circling the key numbers found on the advertisements *(not the page numbers below)* on the free postal cards, pp 553-560.

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Note: This index includes all advertisers whose copy was received by closing date, July 15, 1961. Publisher has made every effort to insure accuracy, but does not assume responsibility for errors or omissions.

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Advertising Sales Manager

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Index to Advertisers

COMPARISONS OF MATERIALS

Specific Gravity[a]

Material	High	Low
Osmium	22.7	—
Iridium	22.5	—
Platinum	21.5	—
Tungsten	19.4	—
Gold	19.3	—
Uranium	19.1	—
Tantalum	16.6	—
Tungsten Carbide Cermet	15.2	13
Hafnium	13	—
Tungsten-Titanium Carbide Cermet	13	10.5
Rhodium	12.4	—
Ruthenium	12.2	—
Palladium	12	—
Thorium	11.6	—
Lead & Its Alloys	11.3	10.7
Lead-Base Babbitts	10.62	9.30
Silver	10.5	—
Molybdenum	10.2	—
Yellow Brasses (cast)	9.96	7.70
Tin Bronzes (cast), High Leaded	9.49	8.85
Cobalt-Base Superalloys	9.13	8.30
Copper	8.95	8.89
Cupro-Nickels	8.94	—
Nickel Brasses & Bronzes (cast), Leaded	8.92	8.82
Silicon Bronzes	8.91	7.09
Red & Semi-Red Brasses (cast), Leaded	8.90	8.56
Chromium Copper	8.88	—
Phosphor Bronzes	8.88	8.74
Cobalt	8.86	—
Gilding, 95%	8.86	—
Tin Bronzes (cast), Leaded	8.85	8.60
Monel	8.84	8.48
Leaded Commercial Bronze	8.83	—
Leaded Brasses	8.82	8.41
Commercial Bronze, 90%	8.8	—
Nickel Silvers	8.74	8.66
Red Brass, 85%	8.74	—
Low Brass, 80%	8.66	—
Cr-Ni-Co-Fe Superalloys	8.60	8.19
Columbium	8.58	—
Tin & Aluminum Brasses	8.53	8.33
Admiralty Brass	8.52	—
Cartridge Brass, 70%	8.52	—
Yellow Brass	8.47	—
Duranickel & Inconel	8.44	8.08
Leaded Naval Brass	8.44	—
Naval Brass	8.41	—
Nickel-Base Superalloys	8.4	7.9
Muntz Metal	8.38	—
Manganese Bronze (A)	8.36	—
Aluminum Brass	8.33	—
Beryllium Copper	8.24	8.18
Low Expansion Nickel Alloys	8.19	8.08
Cr-Ni-Fe Superalloys	8.17	7.88

Material	High	Low
Heat Resistant Alloys (cast)	8.14	7.53
Chromium Carbide Cermet	8.1	6.9
Austenitic Stainless Steels	8.02	7.75
Stainless Steels (cast)	7.99	7.52
Age Hardenable Stainless Steels	7.94	7.63
High Temperature Steels	7.88	7.77
Carbon Steels	7.83	—
Free-Cutting Steels	7.83	—
Low Alloy Steels (cast)	7.83	—
Nitriding Steels	7.83	—
Ultra High Strength Steels	7.83	7.63
Tin-Base Babbitts	7.76	7.34
Ferritic Stainless Steels	7.75	7.47
Low Alloy Steels	7.75	—
Martensitic Stainless Steels	7.75	—
Wrought Irons	7.69	—
Austenitic Nodular Irons	7.43	—
Aluminum Bronzes (cast)	7.33	7.55
Tin & Its Alloys	7.30	7.25
Malleable Irons	7.29	7.13
Nodular Irons	7.21	7.17
Titanium Carbide Cermet	7.2	5.5
Gray Irons	7.19	—
Zinc & Its Alloys	7.17	6.64
Heat Resistant Nodular Irons	6.9	—
Zirconium & Its Alloys	6.64	6.56
Vanadium	6.36	—
Alumina Cermets	6.09	5.81
Molybdenum Disilicide	6	5.9
Titanium & Its Alloys	4.73	4.43
Lead Silicate Glasses	4.3	3
Zircon	3.9	3.4
Alumina Ceramics	3.85	3.45
Micas	3.8	2.6
Epoxies (cast), Ht Res	3.2	1.15
Silicon Carbide	3.1	2.6
Silicon Nitride	3.1	—
Aluminum & Its Alloys (cast)	2.96	2.57
Forsterite	2.9	—
Steatite	2.9	2.5
Aluminum & Its Alloys	2.82	2.62
Aluminum Silicate Fibers	2.7	—
Cordierite	2.7	2.3
Asbestos Fibers	2.6	2.4
Polycrystalline Glass	2.6	2.5
Glass Fibers	2.54	—
Aluminum Silicate Glass	2.5	—
Boron Carbide	2.5	1.9
Soda-Lime Glasses	2.5	—
Standard Electrical Ceramics	2.5	2.4
Epoxies (cast), GP	2.4	1.12
Borosilicate Glasses	2.3	2.1
Fluorocarbon Fiber	2.3	—
TFE Fluorocarbons	2.3	2.1
Alkyds, GP	2.24	2.22

[a] Values represent high and low sides of a range of *typical* values.

Specific Gravity[a]

Material ↓	High	Low	Material ↓	High	Low
Plastics Laminates, Low Pressure	2.2	1.2	Neoprene Rubber	1.25	—
Silica Glasses	2.2	—	Polyvinyl Formal	1.25	1.20
Alkyds, Electrical	2.15	2.05	Silicone Rubber	1.25	—
CFE Fluorocarbons	2.15	2.10	Urethane Rubber	1.25	—
TFE Film	2.15	—	Cellulose Propionate	1.24	1.18
CFE Film	2.11	—	Phenolics (molded)	1.24	3
Boron Nitride	2.1	—	Polycarbonate	1.20	—
Alkyds, Impact	2.08	2	Polyvinyl Butyral	1.20	1.07
Melamines	2	1.43	Acrylics, GP	1.19	1.17
Silicones (molded)	2	1.6	Acrylics, High Impact	1.16	1.12
Hard Rubber	1.95	1.15	Ethyl Cellulose	1.16	1.10
Graphite	1.9	1.4	Ethyl Cellulose Film	1.16	1.14
Beryllium	1.85	—	Rubber Hydrochloride Film	1.15	1.12
Epoxies (molded)	1.85	—	Nylons 6, 11, 66 & 610	1.14	1.09
Plastics Laminates, High Pressure	1.78	1.15	Nylon 6 Film	1.12	—
Magnesium Alloys	1.76	1.68	Polyvinyl Butyral	1.12	1.08
Vinylidene Chloride	1.75	1.68	Modified Polystyrenes	1.11	1.04
Diallyl Phthalate, Asbestos-Filled	1.70	1.65	Nylon Fiber	1.1	—
Vinyl Fibers	1.7	1.3	Imported Woods	1.09	0.14
Polyvinylidene Chloride Film	1.68	—	Polystyrene Film	1.07	1.05
Bast Fibers	1.6	1.5	Polystyrenes, GP	1.07	1.04
Carbon	1.6	1.5	ABS Resins	1.06	1.01
Cotton Fiber	1.6	—	Methylstyrenes	1.06	1.01
Diallyl Phthalate, Glass Fiber-Filled	1.59	1.55	Nitrile Rubber	1	—
Cellophane	1.55	1.40	Polyethylene Fibers	0.96	0.92
Polyvinyl Chloride	1.55	1.16	Polyethylenes, High Density	0.96	0.94
Ureas	1.52	1.47	Polyethylene Film	0.945	0.92
Nylon, Glass-Filled	1.51	1.30	Polyethylenes, Medium Density	0.94	0.93
Cellulosic Fibers	1.5	1.3	Styrene-Butadiene Rubber	0.94	—
Fluorinated Acrylic Rubber	1.5	—	Natural Rubber	0.93	—
Polyvinyl Chloride Film	1.50	1.15	Polyethylenes, Low Density	0.925	0.910
Allyls (cast)	1.46	1.20	Polypropylene	0.91	0.90
Cellulosic Films	1.46	1.16	Polypropylene Fiber	0.91	0.9
Polyesters (cast)	1.46	1.06	Butyl Rubber	0.90	—
Acetal	1.43	—	Polypropylene Film	0.90	0.89
Acrylic Fibers	1.4	1.1	Wood Comp Board, Softboard	0.8	0.2
Animal Fibers	1.4	1.3	American Hardwoods	0.7	0.4
Cellulose Nitrate	1.40	1.35	Wool Felts, Sheet	0.7	0.3
Chlorinated Polyether	1.4	—	American Softwoods	0.5	0.4
Diallyl Phthalate, Dacron Filled	1.4	—	Neoprene Foams	0.48	0.16
Polyester Fibers	1.4	—	Polyethylene Foam, Flexible	0.47	—
Polyvinyl Formal	1.4	1.2	Butadiene-Acrylonitrile Foam	0.4	0.16
Wood Comp Board, Hardboard	1.4	0.08	Urethane Foamed-in-Place, Rigid	0.4	0.008
Polyester Film	1.39	—	Wool Felts, Roll	0.4	0.2
Polysulphide Rubber	1.35	—	Prefoamed Epoxy, Rigid	0.32	0.08
PVC-Nitrile Rubber Blend Film	1.35	1.18	Urethane Foams, Flexible	0.32	0.016
Cellulose Acetate	1.34	1.23	Silicone Foams, Rigid	0.26	0.19
Diallyl Phthalate, Orlon Filled	1.34	1.31	Phenolic Foamed-in-Place, Rigid	0.16	0.03
Phenolics (cast)	1.33	1.31	Polystyrene Foamed-in-Place, Rigid	0.16	0.032
Polystyrenes, Glass-Filled	1.32	1.25	Prefoamed Cellulose Acetate, Rigid	0.13	0.06
Polyvinyl Alcohol	1.31	1.21	Natural Rubber Foam	0.112	0.096
Polyvinyl Alcohol Film	1.31	1.21	Butadiene-Styrene Foams	0.07	—
Wood Comp Board, Particle	1.28	0.42	Prefoamed Polystyrene, Rigid	0.07	0.02
Cellulose Acetate Butyrate	1.25	1.15	Vinyl Foams, Flexible	>0.064	—
Epoxies (cast), Resilient	1.25	—			

[a] Values represent high and low sides of a range of *typical* values.

Electrical Resistivity[a]

Microhm-cm

Material	High	Low
Polyethylenes, Low Density	10^{25}	10^{23}
Polystyrenes, GP	10^{25}	10^{24}
TFE, FEP Fluorocarbons	10^{25}	—
CFE Fluorocarbon	10^{24}	—
Polymethylstyrene	5×10^{23}	2.0×10^{20}
Micas	10^{23}	10^{19}
Modified Polystyrenes	10^{23}	10^{18}
Polypropylene	$>10^{22}$	—
Polystyrenes, Glass-Filled	3.5×10^{22}	—
Polycarbonate	2.1×10^{22}	—
Acrylics, High Impact	2×10^{22}	—
Forsterite	2×10^{22}	—
Polycrystalline Glass	2×10^{22}	6.3×10^{9}
Plastics Laminates, Low Pressure	10^{22}	10^{17}
Polyvinyl Chloride	10^{22}	4×10^{17}
Vinylidene Chloride	10^{22}	10^{20}
Aluminum Silicate Glass[b]	$>10^{21}$	—
Borosilicate Glasses[b]	$>10^{21}$	10^{18}
Lead Silicate Glasses[b]	$>10^{21}$	10^{20}
Polyethylenes, Medium & High Density	$>10^{21}$	—
Silica Glasses[b]	$>10^{21}$	—
Epoxies (molded)	9×10^{21}	10^{20}
Nylon, Glass-Filled	5.5×10^{21}	1.5×10^{21}
Chlorinated Polyether	5×10^{21}	—
Acrylics (cast)	10^{21}	—
Cellulose Propionate	10^{21}	10^{18}
Nylons 6 & 11	10^{21}	10^{18}
Standard Electrical Ceramics	10^{21}	10^{19}
Cordierite	$>10^{20}$	—
Polyvinyl Butyral	$>10^{20}$	—
Steatite	$>10^{20}$	—
Zircon	$>10^{20}$	—
Acrylics, GP	10^{20}	—
Alkyds	10^{20}	—
Epoxies (cast), GP & Ht Res	10^{20}	10^{18}
Ethyl Cellulose	10^{20}	10^{18}
Melamines, GP	10^{20}	10^{18}
ABS Resins	$>8 \times 10^{19}$	0.5×10^{19}
Silicones (molded)	$>5 \times 10^{19}$	$>3.4 \times 10^{19}$
Acetal	$>4 \times 10^{19}$	—
Nylons 66 & 610	4.5×10^{19}	—
Boron Nitride	1.7×10^{19}	—
Allyls (cast)	$>10^{19}$	—
Cellulose Acetate	10^{19}	10^{16}
Melamines, Elec	10^{19}	10^{17}
Phenolics, Elec	10^{19}	6×10^{18}
Phenolics (molded), GP	10^{19}	10^{15}
Polyesters (cast), Rigid	10^{19}	—
Phenolics (cast), Mech & Chem	7×10^{18}	10^{18}
Cellulose Acetate Butyrate	10^{18}	10^{16}
Melamines, Shock Res	10^{18}	10^{15}
Phenolics (molded), Very High Shock	10^{18}	—
Polyesters (cast), Nonrigid	10^{18}	—
Ureas	5×10^{17}	5×10^{16}
Methylstyrene-Acrylonitrile	2.6×10^{17}	—
Cellulose Nitrate	1.5×10^{17}	10×10^{16}
Rubber Phenolics	10^{17}	10^{12}
Melamines, Glass Fiber-Filled	7×10^{16}	—
Diallyl Phthalate	2.5×10^{16}	10^{14}
Soda-Lime Glasses[b]	4×10^{15}	—
Beryllium Carbide	1.1×10^{6}	—
Carbon	4600	3500
Graphite	1300	800
Gray Irons	200	50
Titanium & Its Alloys	176	90
Nickel-Base Superalloys	148	118
Heat Resistant Alloys (cast)	112	70
Titanium Carbide	105	—
Cr-Ni-Fe Superalloys[b]	104	91
Austenitic Nodular Irons	102	—
Age Hardenable Stainless Steels	98	75.7
Cobalt-Base Superalloys	93	23.7
Stainless Steels (cast)	90	71
Low Expansion Nickel Alloys	81	48
Austenitic Stainless Steels	78	69
Columbium Carbide	74	—
Zirconium & Its Alloys	74	40
Martensitic Stainless Steels	72	40
Nodular Irons	68	66
Ferritic Stainless Steels	67	60
Nickel & Its Alloys[c]	65.3	8.3
Zirconium Carbide	63.4	—
Uranium	50	25
Pearlitic Malleable Irons	41.2	38.2
Cupro-Nickels	37	15
Standard Malleable Irons	32	—
Hafnium[c]	30	—
Low Alloy Steels (43XX, 48XX)	30	—
Nitriding Steels	29	27
Tin-Lead-Antimony Alloys	28.7	25.6
Low Alloy Steels (23XX)	28.4	—
Molybdenum Disilicide	27.2	21.5
Hard Leads	27.1	22
Vanadium	25	—
Low Alloy Steels (41XX)	22.3	—
Low Alloy Steels (51XX, 61XX)	21	—
Soft Leads	20.6	—
Low Alloy Steels (cast)	20	15
Tantalum Carbide	20	—
Carbon Steels	19	14.3
Low Alloy Steels (40XX)	19	—
Thorium	18	—
Low Alloy Steels (13XX)	17	—
Magnesium Alloys	17	5
Carbon Steels (cast)	16	13
Phosphor Bronzes	16	3.6
White Metal	15	—
Platinum	14.9	—
Free-Cutting Steels	14.3	—
Columbium	14.2	—
Tantalum	12.4	—
Wrought Irons	11.97	—
Grade A Tin	11.5	—
Palladium[c]	10.8	—
Osmium	9.5	—
Admiralty Metal, Ann.	8.9	—
Ruthenium[c]	7.6	—
Tin & Aluminum Brasses	7.5	6.6
Leaded Brasses	6.6	4.1
Zinc Alloys (cast)	6.54	6.37
Yellow Brass, Ann.	6.4	—
Aluminum & Its Alloys	6.3	2.8
Cartridge Brass, 70%, Ann.	6.2	—
Zinc, CR	6.1	—
Zinc, HR	6.06	—
Beryllium Copper	5.82	4.82
Tungsten[c]	5.48	—
Low Brass, 80%, Ann.	5.4	—
Iridium	5.3	—
Molybdenum[c]	5.17	—
Beryllium	5	—
Rhodium	4.51	—
Red Brass, 85%, Ann.	4.7	—
Commercial Bronze, 90%, Ann.	3.9	—
Gilding, 95%, Ann.	3.1	—
Gold[c]	2.35	—
Copper	2.03	1.71
Silver	1.59	—

[a] Values represent high and low sides of a range of *typical* values at room temperature except where noted.
[b] At temperatures between 120 and 212 F. [c] At 32 F.

Dielectric Strength of Nonmetallics[a]

v/mil

Material ↓	High	Low
Micas, Natural & Synthetic	2000	1000
Polymethylstyrene	1950	890
Polyvinyl Chloride	1400	24
Polyvinyl Formal	1000	860
Plastics Laminates, High Pressure	1000	70
Polypropylene	820	769
Plastics Laminates, Low Pressure	800	100
Modified Polystyrenes	650	300
Methylstyrene-Acrylonitrile	610	—
Cellulose Acetate	600	250
Cellulose Nitrate	600	300
CFE Fluorocarbons	600	530
Hard Rubber	600	344
Mica, Glass-Bonded	600	270
Polyesters (cast), Rigid	570	340
Epoxies (cast)	550	350
Acrylics	530	400
Polystyrenes, GP	>500	—
Acetal	500	—
Ethyl Cellulose	500	350
Nylon, Glass-Filled	500	400
Nylons 6 & 11	500	420
Polyesters (cast), Allyl Type	500	330
TFE Fluorocarbons	500	400
Polyethylenes	480	—
Nylons 66 & 610	470	385
Epoxies (molded)	468	334
Cellulose Propionate	450	300
Diallyl Phthalate	450	275
Phenolics (cast), GP Decorative	450	300
Melamines, Elec.	430	350
Phenolics (molded), GP	425	200
Polystyrenes, Glass-Filled	425	340
ABS Resins, High Impact	416	350
Cellulose Acetate Butyrate	400	250
Chlorinated Polyether	400	—
Melamines, Cellulose Elec	400	350
Phenolics (cast), Mech & Chem	400	350
Polycarbonate	400	—
Polyesters (cast), Nonrigid	400	220
Polyvinyl Butyral	400	—
Silicones (molded)	400	250
Ureas	400	300
Rubber Phenolics	375	250
Melamines, Shock Res	370	130
Phenolics (molded), Very High Shock	370	200
Alkyds	350	300
Polycrystalline Glass	350	250
Phenolics, Ht Res	350	100
Melamines, GP	330	310
ABS Resins, Extra High Impact	312	—
Alumina Ceramics	300	200
Standard Electrical Ceramics	300	55
Zircon	290	60
Steatite	280	145
Forsterite	250	—
Phenolics (cast), GP Transparent	250	75
Cordierite	230	140
Polyethylene Foam, Flexible	220	—

[a] Values represent high and low sides of a range of *typical* values.

Dielectric Constant of Nonmetallics[a]

Material ↓	High	Low
Mica, Glass-Bonded	40	6.9
Phenolics (cast)	11	4
Alumina Ceramics	9.6	8.2
Lead Silicate Glass	9.5	6.6
Zircon	9.2	5.3
Polyvinyl Chloride	9.1	2.3
Micas, Natural & Synthetic	8.7	5.4
Phenolics (molded)	8	4
Soda-Lime Glass	7.4	7.2
Melamines	7.2	4.7
Cellulose Acetate	7	3.2
Standard Electrical Ceramics	7.0	5.4
Ureas	6.9	6.4
Plastics Laminates, High Pressure	6.8	3.3
Forsterite	6.5	6.2
Steatite	6.5	5.5
Cellulose Nitrate	6.4	—
Aluminum Silicate Glass	6.3	—
Cellulose Acetate Butyrate	6.2	3.2
Cordierite	6.2	4
Polyesters (cast), Nonrigid	6.1	3.7
Plastics Laminates, Low Pressure	5.6	3.4
Polycrystalline Glass	5.6	—
Borosilicate Glass	5.1	4
Silicones (molded)	5.1	3.6
Alkyds, GP	5	4.8
Rubber Phenolics	5	—
Vinylidene Chloride	5	3
Hard Rubber	4.95	2.90
Polyesters (cast), Allyl Type	4.8	3.3
Alkyds, Elec & Impact	4.5	4.2
Diallyl Phthalate	4.5	3.3
Nylons 6 & 11	4.5	3.5
Epoxies (cast)	4.4	2.6
Epoxies, GP	4.4	3.4
Boron Nitride	4.2	—
ABS Resins, Low Temp Impact	4.1	2.8
Epoxies, Ht Res	4	3.5
Modified Polystyrenes	4	2.5
Polyesters (cast), Rigid	4	2.8
Nylon, Glass-Filled	3.9	3.4
Silica Glass	3.8	—
ABS Resins, Extra High Impact	3.78	—
Acetal	3.7	—
ABS Resins, High Impact	3.6	2.8
Cellulose Propionate	3.6	3.4
Ethyl Cellulose	3.6	2.8
Nylons 66 & 610	3.6	3.4
Polystyrenes, Glass-Filled	3.41	2.74
Modified Polystyrenes, Extra High Impact	3.3	1.9
Polyvinyl Butyral	3.3	—
Acrylics	3.2	2.7
Polyvinyl Formal	3	—
Polycarbonate	2.96	—
Chlorinated Polyether	2.92	—
Methylstyrene-Acrylonitrile	2.81	—
Epoxies, Resilient	2.8	2.6
Polystyrenes, GP	2.65	2.45
Polymethylstyrene	2.48	—
CFE Fluorocarbons	2.37	2.30
Polyethylenes	2.3	—
Polypropylene	2.1	2
TFE Fluorocarbons	2	—
Prefoamed Epoxy, Rigid	1.55	1.19
Polyethylene Foam, Flexible	1.49	—
Urethane Rubber Foamed-in-Place, Rigid	1.40	1.05
Silicone Foams, Rigid	1.26	1.23
Polystyrene Foamed-in-Place, Rigid	1.19	—
Prefoamed Cellulose Acetate, Rigid	1.12	1.10
Prefoamed Polystyrene, Rigid	<1.07	—

[a] Values represent high and low sides of a range of *typical* values at 10^6 cycles.

Thermal Conductivity[a]

Btu/hr/sq ft/°F/ft

Material	High	Low	Material	High	Low
Silver[b]	242	—	Austenitic Stainless Steels[b]	9.4	8
Copper	226	196	Columbium Carbide	8.2	—
Chromium Copper	187	—	Carbon[b]	5	3
Gold[b]	172	—	Calcia[d]	4.1	—
Aluminum & Its Alloys	135	67.4	Zircon	3.6	2.9
Plain Brasses	135	67	Cordierite & Forsterite	2.4	0.9
Graphite[b]	120	70	Polycrystalline Glass	2.1	1.1
Phosphor Bronzes	120	29	Steatite	1.94	1.45
Beryllium Copper	110	100	Electrical Ceramics	1.6	0.9
Leaded Brasses	104	67	Magnesia[d]	1.5	—
Tungsten[b]	96.6	—	Wood Comp Board	1.5	0.08
Aluminum & Its Alloys (cast)	92.5	51.0	Wool Felts (1 in.), Sheet	0.91	0.30
Beryllium[b]	87	—	Silicon Nitride[d]	0.9	—
Molybdenum[b]	84.5	—	Epoxies (cast)	0.8	0.1
Magnesium Alloys	80	24	Silica Glasses[b]	0.8	—
Tin & Aluminum Brasses	67	58	Silica, Vitreous[d]	0.8	—
Zinc & Its Alloys	65.3	60.5	Borosilicate Glasses[b]	0.7	—
Tungsten Carbide Cermet	50.1	25.7	Alkyds	0.60	0.20
Rhodium[b]	50	—	Wood Comp Board, Softboard	0.6	0.3
Platinum[b]	42	—	Lead Silicate & Soda-Lime Glasses[b]	0.5	—
Palladium[b]	41	—	Zirconia[d]	0.5	—
Low Alloy Steels[b]	38.5	21.7	Polyvinyl Alcohol	0.46	—
Tin & Its Alloys	37	34	Melamines	0.41	0.17
Nickel & Its Alloys[b]	36	8.7	Micas	0.4	0.2
Wrought Irons[b]	34.5	—	Phenolics (molded)	0.39	0.10
Gray Irons (cast)[b]	34	24	Wool Felts (1 in.), Roll	0.39	0.24
Iridium[b]	34	—	Plastics Laminates, High Pressure	0.29	0.17
Aluminum Bronzes (cast)	33	22	Ureas	0.24	0.17
Tungsten-Titanium Carbide Cermet	32.9	16.5	Cellulose Acetate & Propionate	0.19	0.10
Columbium & Tantalum[b]	31.5	—	Polyethylenes	0.19	—
Silicon Bronzes	31	20	Ethyl Cellulose	0.17	0.09
Nitriding Steels[b]	30	—	CFE Fluorocarbons	0.145	—
Malleable Irons	29.5	—	Nylons 6, 11, 66 & 610	0.14	0.10
Alumina Cermets[c]	29	—	Styrene-Butadiene & Nitrile Rubber	0.14	—
Silicon Carbide[d]	29	9	TFE Fluorocarbons	0.14	—
Tin Bronzes (cast), Leaded	28	—	Acetal	0.13	—
Carbon & Free-Cutting Steels[b]	27	—	Cellulose Nitrate	0.13	—
Low Alloy Steels (cast)[b]	27	—	ABS Resins	0.12	0.08
Tin Bronzes (cast), High Leaded	27	—	Acrylics	0.12	0.10
Cupro-Nickels & Nickel Silvers	26	17	Nylon, Glass-Filled	0.12	—
Thorium	21.4	—	Polyesters (cast)	0.12	0.10
Martensitic Stainless Steels[b]	21.2	11.7	Silicone Rubber	0.12	0.11
Nodular or Ductile Irons[b]	20	18	Neoprene Rubber	0.11	—
Lead & Its Alloys[b]	19.6	16.0	Polycarbonate	0.11	—
Cobalt-Base Superalloys[c]	18.0	11.9	Polyvinyl Chloride	0.10	0.07
High Temperature Steels[c]	17.3	15.8	Silicones (molded)	0.097	0.089
Boron Nitride[c]	16.6	—	Polyvinyl Formal	0.09	—
Ultra High Strength Steels[c]	16.6	—	Natural Rubber	0.08	—
Boron Carbide[d]	16	—	Polypropylene	0.08	—
Heat Resistant Alloys (cast)[b]	51.2	7.7	Polystyrenes, GP	0.08	0.06
Ferritic Stainless Steels[b]	15.1	12.1	Modified Polystyrenes	0.07	0.02
Cr-Ni-Fe Superalloys[c]	15	12.2	Butyl Rubber	0.05	—
Nickel-Base Superalloys[c]	15	9.5	Vinylidene Chloride	0.05	—
Stainless Steels (cast)[b]	14.5	8.2	Urethane Foamed-in-Place, Rigid	0.03	0.01
Uranium	14.5	—	Neoprene Foams	0.029	0.021
Tin-Lead-Antimony Alloys[b]	14	—	Prefoamed Cellulose Acetate, Rigid	0.027	0.025
Tantalum Carbide	12.8	—	Butadiene-Acrylonitrile Foams	0.025	0.021
Age Hardenable Stainless Steels[b]	12.1	8.87	Natural Rubber Foam	0.025	0.021
Zirconium Carbide	11.9	—	Silicone Foams, Rigid	0.025	—
Alumina Ceramics[b]	10.7	6.2	Phenolic Foamed-in-Place, Rigid	0.02	—
Low Expansion Nickel Alloys[b]	10.3	7.8	Polystyrene Foamed-in-Place, Rigid	0.02	—
Titanium Carbide	9.9	—	Prefoamed Epoxy, Rigid	0.02	—
Titanium & Its Alloys[b]	9.8	4.3	Prefoamed Polystyrene, Rigid	0.02	—
Zirconium & Its Alloys[b]	9.6	8.1	Butadiene-Styrene Foams	0.018	—
Beryllia[d]	9.52	—	Thoria[d]	0	—

[a] Values represent high and low sides of a range of *typical* values at room temperature except where noted.
[b] At temperatures between 20 and 212 F. [c] At temperatures between 212 and 1800 F. [d] At temperatures above 1800 F.

Coefficient of Thermal Expansion[a]

10^{-6} in./in./°F

Material	High	Low
Silicone Rubber	670	—
Nitrile Rubber	390	—
Natural Styrene-Butadiene Rubber	370	—
Neoprene Rubber	340	—
Butyl Rubber	320	—
Polyethylenes, Medium & High Density	167	83
Polyvinyl Butyral	127	44
Ethyl Cellulose	110	55
Polyethylenes, Low Density	110	89
Cellulose Acetate & Propionate	90	44
Vinylidene Chloride	87.8	—
Nylons 6 & 11	71	46
Polyvinyl Alcohol	66.5	38.8
Cellulose Nitrate	66	44
Phenolics (cast)	66	33
Polypropylene	62	—
ABS Resins and Modified Polystyrenes	56	22
Polyesters (cast)	56	28
Nylons 66 & 610	55	—
TFE Fluorocarbons	55	—
Acrylics and Epoxies (cast)	50	30
Urethane Foams	50	14
Acetal and Chlorinated Polyether	45	44
Polystyrenes, GP	44	33
Polyvinyl Formal	42.7	35.5
Polycarbonate	39	—
CFE Fluorocarbons	38.8	—
Diallyl Phthalate	35	15
Silicones (molded)	32.2	4.5
Melamines and Alkyds	31.7	8.2
Micas, Natural & Synthetic[b]	27	18
Phenolics (molded)	25	8.3
Prefoamed Cellulose Acetate, Rigid	25	20
Prefoamed Polystyrene, Rigid	25	—
Polystyrenes, Glass-Filled	24	22
Prefoamed Epoxy, Rigid	22	16
Mica, Glass-Bonded[b]	20	5.8
Zinc & Its Alloys[c]	19.3	10.8
Nylon, Glass-Filled	17	12.5
Plastics Laminates, High Pressure	17	5.5
Lead & Its Alloys[c]	16.3	14.4
Magnesium Alloys[b]	16	14
Ureas	15	12
Tin-Lead-Antimony Alloys[c]	14.6	10.9
Epoxies (molded)	14	—
Plastics Laminates, Low Pressure	14	10
Aluminum & Its Alloys[c]	13.7	11.7
Tin & Its Alloys[c]	13	—
Uranium[c]	12.1	—
Tin & Aluminum Brasses[c]	11.8	10.3
Plain & Leaded Brasses[c]	11.6	10
Silver[c]	10.9	—
Cr-Ni-Fe Superalloys[d]	10.5	9.2
Heat Resistant Alloys (cast)[d]	10.5	6.4
Nodular or Ductile Irons (cast)[c]	10.4	6.6
Stainless Steels (cast)[d]	10.4	6.4
Tin Bronzes (cast)[c]	10.3	10
Austentic Stainless Steels[c]	10.2	9
Phosphor Bronzes[c]	10.2	9.6
Silicon Bronzes[c]	10	9.8
Coppers[c]	9.8	—
Nickel-Base Superalloys[d]	9.8	7.7
Aluminum Bronzes (cast)[c]	9.5	9
Cobalt-Base Superalloys[d]	9.4	6.8
Beryllium Copper[c]	9.3	—
Cupro-Nickels & Nickel Silvers[c]	9.3	9
Nickel & Its Alloys[d]	9.2	6.8
Cr-Ni-Co-Fe Superalloys[d]	9.1	8
Low Alloy Steels[d]	8.6	6.3
Carbon Free-Cutting Steels[d]	8.4	8.1
Low Alloy Steels (cast)[d]	8.3	8
Age Hardenable Stainless Steels[c]	8.2	5.5
Gold[c]	7.9	—
High Temperature Steels[d]	7.9	6.3
Magnesia[e]	7.8	—
Ultra High Strength Steels[d]	7.61	5.68
Calcia[e]	7.6	—
Malleable Irons[c]	7.5	5.9
Titanium Carbide Cermet[d]	7.5	4.3
Wrought Irons[c]	7.4	—
Titanium & Its Alloys[d]	7.1	4.9
Cobalt[d]	6.8	—
Martensitic Stainless Steels[c]	6.5	5.5
Nitriding Steels[d]	6.5	—
Palladium[c]	6.5	—
Beryllium[b]	6.4	—
Chromium Carbide Cermet[c]	6.3	5.8
Thorium[b]	6.2	—
Ferritic Stainless Steels[c]	6	5.8
Gray Irons (cast)[c]	6	—
Beryllium Carbide[d]	5.8	—
Low Expansion Nickel Alloys[c]	5.5	1.5
Beryllia & Thoria[e]	5.3	—
Alumina Cermets[d]	5.2	4.7
Lead Silicate Soda-Lime Glasses[c]	5.1	4.8
Molybdenum Disilicide[e]	5.1	—
Ruthenium[b]	5.1	—
Platinum[c]	4.9	—
Vanadium[b]	4.8	—
Forsterite[c]	4.7	—
Rhodium[b]	4.6	—
Tantalum Carbide[d]	4.6	—
Boron Nitride[d]	4.3	—
Titanium Carbide[d]	4.1	—
Polycrystalline Glass[c]	4	0.2
Steatite[e]	4	3.3
Tungsten Carbide Cermet[c]	3.9	2.5
Columbium[d]	3.82	—
Iridium[b]	3.8	—
Alumina Ceramics[e]	3.7	3.1
Zirconium Carbide[d]	3.7	—
Osmium and Tantalum[b]	3.6	—
Zirconium & Its Alloys[b]	3.6	3.1
Hafnium[b]	3.4	—
Polyvinyl Chloride	3.3	2.8
Zirconia[e]	3.1	—
Molybdenum[b]	3	—
Borosilicate Glasses[c]	2.5	1.8
Aluminum Silicate Glass[c]	2.3	—
Silicon Carbide[e]	2.2	2.4
Tungsten[b]	2.2	—
Cordierite[c]	2.1	—
Electrical Ceramics[e]	2	—
Zircon[e]	1.8	1.3
Boron Carbide[e]	1.7	—
Carbon and Graphite[c]	1.5	1.3
Silicon Nitride[d]	1.4	—
Silica Glasses[e]	0.5	0.3
Silica, Vitreous[e]	0.28	—
Wool Felts[b]	0	—

[a] Values represent high and low sides of a range of *typical* values. Values for plastics materials are for a range of temperatures between −22 and 86F (ASTM D696). [b] Value at room temperature only.
[c] Value for a temperature range between room temperature and 212–750 F.
[d] Value for a temperature range between room temperature and 1000–1800 F.
[e] Value for a temperature range between room temperature and 2200–2875 F.

Melting Points of Metals and Ceramics[a]

Fahrenheit

Material	High	Low
Tungsten	6152	—
Thoria	6000	—
Tantalum	5425	—
Magnesia	5070	—
Osmium	4890	—
Molybdenum	4760	—
Calcia & Zirconia	4710	—
Beryllia	4620	—
Ruthenium	4530	—
Iridium	4450	—
Columbium	4379	—
Molybdenum Disilicide	3775	3595
Rhodium	3571	—
Silicon Nitride	3452	—
Hafnium	3400	—
Alumina Cermets	3362	—
Zirconium & Its Alloys	3355	3300
Platinum	3224	—
Thorium	3180	—
Titanium & Its Alloys	3135	2730
Vanadium	3110	—
Fused Silica Glass	3050	—
Boron Nitride	>3000	—
Palladium	2829	—
Martensitic Stainless Steels	2800	2500
96% Silica Glass	2800	—
Ferritic Stainless Steels	2790	2600

Material	High	Low
Carbon Steels	2775	2700
Low Alloy Steels	2760	2600
Heat Resistant Alloys (cast)	2750	2350
High Temperature Steels	2750	2660
Stainless Steels (cast)	2750	2550
Wrought Irons	2750	—
Cobalt	2723	—
Cr-Ni-Fe Superalloys	2664	2225
Austenitic Stainless Steels	2650	2500
Nickel & Its Alloys	2635	2300
Low Expansion Nickel Alloys	2606	2600
Nickel-Base Superalloys	2600	2318
Cobalt-Base Superalloys	2570	1600
Age Hardenable Stainless Steels	2550	2500
Cr-Ni-Co-Fe Superalloys	2470	2350
Beryllium	2341	—
Cupro-Nickels	2260	2020
Austenitic Nodular Irons	2250	—
Chromium Copper	2147	—
Uranium	2071	—
Heat Resistant Nodular Irons	2150	2050
Nickel Silvers	2030	1870
Silicon Bronzes	1990	1780
Coppers	1981	1949

Material	High	Low
Phosphor Bronzes	1970	1550
Gilding, 95%	1950	1920
Gold	1945	—
Aluminum Bronzes (cast)	1937	1880
Commercial Bronze	1910	1870
Leaded Brasses	1900	1610
Tin Bronzes (cast), Leaded	1830	1570
Beryllium Copper	1800	1600
Tin Bronzes (cast), High Leaded	1800	1700
Tin & Aluminum Brasses	1780	1590
Silver	1761	—
Aluminum Silicate Glass	1675	—
Borosilicate Glass	1500	1300
Soda-Lime Glass	1330	1285
Aluminum & Its Alloys	1215	935
Magnesium Alloys	1200	830
Aluminum & Its Alloys (cast)	1195	910
Lead Silicate Glasses	1160	1075
Tin-Lead-Antimony Alloys	792	358
Zinc & Its Alloys	792	727
Soft Lead	623	617
Hard Lead Alloys	610	490
Pewter	565	475
Lead-Base Babbitts	540	460
White Metal	475	—
Hard Tin	443	—

[a] Values represent high and low sides of a range of *typical* values.

Maximum Service Temperatures of Plastics and Rubber[a]

Fahrenheit

Material	High	Low
Silicones (molded)	>700	>600
TFE Film	585	566
Silicone Rubber	550	—
Plastics Laminates, Low Pressure	500	250
TFE Fluorocarbons	500	—
Polyester Film	490	—
Diallyl Phthalate	450	300
Fluorinated Acrylic Rubber	450	—
Phenolics, Shock & Ht Res	450	250
Viton Rubber	450	—
Cellulosic Films	400	140
Epoxies (cast), Ht Res	400	—
FEP Fluorocarbons	400	—
Melamines, Glass-Filled	400	300
Nylon, Glass-Filled	400	300
Phenolics (molded), Shock & Heat	400	350
Plastics Laminates, Elec	400	160
Urethane Foamed-in-Place, Rigid	400	—
CFE Film	395	300
Melamines, Cellulose or Mineral-Filled	395	205
CFE Fluorocarbons	380	—
Nylon 6 Film	380	—
Alkyds, High Str	350	—
Phenolics (molded), GP	350	300

Material	High	Low
Prefoamed Cellulose Acetate, Rigid	350	200
Alkyds, GP	345	295
Alkyds, Elec	300	—
Allyls (cast)	300	—
Butyl Rubber	300	—
Diallyl Phthalate, Orlon-Filled	300	—
Nylons 66 & 610	300	225
Phenolic Foamed-in-Place, Rigid	300	—
Polypropylene Film	300	—
Rubber Phenolics	300	212
Plastics Laminates, GP	295	245
Polyester (cast), Rigid	295	245
Polyvinylidene Chloride Film	290	—
Melamines, Fabric-Filled	250	—
Melamines, Shock Res	250	—
Nitrile Rubber	250	—
Nylons 6 & 11	250	200
Polyethylene Film	250	200
Polysulfide Rubber	250	—
Neoprene Rubber	240	—
Urethane Rubber	240	—
Polyvinyl Chloride	220	140
Methylstyrenes	212	210
Vinylidene Chloride	212	170
Melamines, GP	210	—

Material	High	Low
Butadiene-Acrylonitrile Foams	210	—
Rubber Hydrochloride Film	205	—
Acrylics	200	140
Polystyrenes, Glass-Filled	200	190
PVC-Nitrile Rubber Blend Film	200	—
Urethane Foams, Flexible	200	—
Modified Polystyrenes	190	120
Acetal	185	—
Polystyrene Foamed-in-Place, Rigid	185	—
Natural Rubber	180	—
Neoprene Foams	180	—
Polystyrenes, GP	180	140
Polyvinyl Chloride Film, Nonrigid	180	150
Styrene-Butadiene Rubber	180	—
Epoxies (cast), GP	175	—
Prefoamed Polystyrene, Rigid	175	155
Polyvinyl Formal	165	130
Butadiene-Styrene Foams	160	—
Natural Rubber Foam	160	—
Cellulose Nitrate	140	120
Epoxies (cast), Resilient	122	—
Polyvinyl Butyral	115	—

[a] Values represent high and low sides of a range of *typical* values.

Specific Heat[a]

Btu/lb/°F

Material	High	Low	Material	High	Low
Nylon 6 & 11	0.6	0.4	Low Expansion Nickel Alloys	0.123	0.120
Allyl (cast)	0.56	0.26	Austenitic Stainless Steels	0.12	—
Polyester, Rigid	0.56	0.30	Cobalt-Base Superalloys	0.12	0.09
Polyethylenes	0.55	0.46	Ferritic Stainless Steels	0.12	0.11
Nylon 66 & 610	0.5	0.3	Low Alloy Steels	0.12	0.10
Polypropylene	0.46	—	Nitriding Steels	0.12	0.11
Beryllium	0.45	—	Vanadium	0.12	—
Cellulose Acetate	0.42	0.3	Carbon Steels	0.11	0.10
Cellulose Acetate Butyrate	0.4	0.3	Cr-Ni-Fe Superalloys	0.11	0.10
Cellulose Propionate	0.4	0.3	Free-Cutting Steels	0.11	0.10
Phenolics, GP	0.40	0.36	Low Alloy Steels (cast)	0.11	0.10
Polyvinyl Butyral	0.4	—	Martensitic Stainless Steels	0.11	—
ABS Resins	0.38	0.35	Nickel-Base Superalloys	0.11	0.09
Acetal	0.35	—	Wrought Irons	0.11	—
Acrylics	0.35	0.34	Inconel	0.109	—
Modified Polystyrenes	0.35	0.30	Cr-Ni-Co-Fe Superalloys	0.108	0.10
Nylon, Glass-Filled	0.35	0.30	Beryllium Copper	0.10	—
Phenolics, High Shock	0.35	0.31	Copper Alloys	0.10	0.09
Polystyrene, GP	0.35	0.33	Nickel & Its Alloys	0.10	0.13
Rubber Phenolics	0.33	—	Zinc & Its Alloys	0.10	0.95
Silicon Carbide	0.33	0.29	Cupro-Nickels	0.09	—
Phenolics, Very High Shock	0.32	0.28	Leaded Brasses	0.09	—
Vinylidene Chloride	0.32	—	Nickel Silvers	0.09	—
Polyvinyl Alcohol	0.3	—	Phosphor Bronzes	0.09	—
Polystyrenes, Glass-Filled	0.27	0.24	Plain Brasses	0.09	—
Prefoamed Polystyrene, Rigid	0.27	—	Silicon Bronzes	0.09	—
Micas	0.25	0.13	Tin & Aluminum Brasses	0.09	—
TFE Fluorocarbons	0.25	—	Zircon & Its Alloys	0.07	—
Magnesium Alloys	0.245	—	Columbium	0.065	—
Aluminum & Its Alloys	0.23	0.22	Molybdenum	0.65	—
CFE Fluorocarbons	0.22	—	Tin-Lead-Antimony Alloys	0.065	—
Borosilicate Glass	0.2	—	Rhodium	0.059	—
Soda-Lime Glass	0.2	—	Palladium	0.058	—
Fused Silica Glass	0.19	—	Ruthenium	0.057	—
Polycrystalline Glass	0.19	0.18	Silver	0.056	—
Aluminum Silicate Glass	0.18	—	Tin & Its Alloys	0.05	—
Carbon	0.18	—	Tantalum	0.036	—
Graphite	0.18	—	Hafnium	0.035	—
96% Silica Glass	0.18	—	Tungsten	0.034	—
Lead Silicate Glass	0.17	0.16	Lead & Its Alloys	0.032	0.031
Alumina Cermets	0.16	0.14	Gold	0.031	—
Heat Resistant Alloys (cast)	0.14	0.11	Iridium	0.031	—
Stainless Steels (cast)	0.14	0.11	Osmium	0.031	—
Malleable Irons	0.13	—	Platinum	0.031	—
Titanium & Its Alloys	0.13	0.12	Thorium	0.03	—
Monel	0.127	—	Uranium	0.03	—

[a] Values represent high and low sides of a range of *typical* values.

Modulus of Elasticity in Tension*

100,000 psi

Material ↓	High	Low	Material ↓	High	Low
Tungsten Carbide Cermet	943	616	Tellurium Copper	160	—
Tungsten-Titanium Carbide Cermet	806	655	Tin & Aluminum Brasses	160	150
Osmium	800	—	Zirconium & Its Alloys	140	138
Iridium	740	—	Aluminum Silicate Glass	127	—
Silicon Carbide	680	132	Boron Nitride	124	—
Ruthenium	600	—	Gold	120	—
Titanium Carbide Cermet	570	420	Mica, Glass-Bonded	120	70
Alumina Ceramics	500	320	Silver	110	—
Tungsten	500	—	Aluminum & Its Alloys	106	100
Beryllium	440	—	Fused Silica Glass	102	—
Boron Carbide	420	—	Soda-Lime Glass	100	90
Molybdenum	420	—	Standard Electrical Ceramics	100	—
Rhodium	420	—	Thorium	100	—
Alumina Cermets	410	370	Borosilicate Glass	98	68
Cobalt-Base Superalloys	360	270	96% Silica Glass	97	—
High Temperature Steels	316	290	Lead Silicate Glass	90	76
Cr-Ni-Co-Fe Superalloys	311	288	Pewter	77	—
Inconel	310	—	Tin-Base Babbitts	76	72
Carbon Steels	300	290	Cordierite	70	—
Cobalt (cast)	300	—	Grade A Tin	65	60
Low Alloy Steels (cast)	300	290	Magnesium Alloys	65	64
Mica, Natural	300	200	Phenolics, Elec	50	30
Nickel & Its Alloys	300	190	Lead-Base Babbitts	42	—
Nitriding Steels	300	290	Nickel-Base Superalloys	35.5	28
Ultra High Strength Steels	300	294	Phenolics, Shock & Ht Res	33	8
Uranium	300	—	Lead & Its Alloys	20	15
Cr-Ni-Fe Superalloys	299	280	Melamines, Filled	19.5	9.9
Wrought Irons	295	—	Titanium & Its Alloys	17.5	13
Age Hardenable Stainless Steels	294	280	Ureas	16	13
Austenitic Stainless Steels	290	280	Phenolics, GP	13	7
Ferritic Stainless Steels	290	—	Polystyrenes, Glass-Filled	13	11
Free-Cutting Steels	290	—	Tin Bronzes (cast), High Leaded	13	8.5
Heat Resistant Alloys (cast)	290	250	Diallyl Phthalate	12	6
Martensitic Stainless Steels	290	—	Rubber Phenolics	9	3
Stainless Steels (cast)	290	240	Nylon, Glass-Filled	8.6	1.2
Pearlitic Malleable Irons	280	—	Polyvinyl Formal	7	5
Tantalum	270	—	Modified Polystyrenes	6	2.5
Monel	260	—	Acrylics, GP	5	3.5
Mica, Synthetic	250	—	Phenolics (cast), Mech & Chem	5	4
Standard Nodular or Ductile Irons	250	185	Polystyrenes, GP	5	4
Standard Malleable Irons	250	—	Phenolics (cast), Decorative	4.5	3
Low Expansion Nickel Alloys	240	210	Nylon 66 & 610	4.1	1.6
Cupro-Nickels	220	180	Polyvinyl Butyral	4	3.5
Platinum	210	—	Nylon 6 & 11	3.6	1.5
Zircon	210	—	Ethyl Cellulose	3.5	0.5
Gray Irons	200	90	Acrylics, High Impact	3	2.2
Hafnium & Vanadium	200	—	Allyls (cast)	3	2
Austenitic Nodular Irons	185	—	CFE Fluorocarbons	3	1.9
Aluminum Bronzes (cast)	180	150	Phenolics (cast), Transparent	3	1
Nickel Silvers	180	175	ABS Resins	2.9	1
Silicon Bronzes	180	150	Carbon	2.3	1.6
Polycrystalline Glass	173	125	Cellulose Nitrate	2.2	1.9
Copper	170	—	Vinylidene Chloride	2	0.7
Gilding, 95% & Commercial			Graphite	1.8	0.5
Bronze, 90%	170	—	Polypropylene	1.55	—
Leaded Brasses	170	140	TFE Fluorocarbons	0.65	0.38
Palladium	170	—	Polycarbonate	0.33	—
Phosphor Bronzes	170	150	Polyethylene, Low Density	0.27	0.20
Steatite	160	130	Polyvinyl Chloride, Nonrigid	0.030	0.004

* Values represent high and low sides of a range of *typical* values at room temperature.

Yield Strength of Metals[a]

1000 psi

Material ↓	High	Low
Martensitic Stainless Steels, H & T	275	60
Ultra High Strength Steels, H & T	250	239
Low Alloy Steels (40XX), H & T	231	85
Low Alloy Steels (92XX), H & T	226	215
Age Hardenable Stainless Steels, Sol'n Tr & Aged	225	42
Titanium & Its Alloys, Ht Tr	220	150
Low Alloy Steels (41XX), H & T	215	170
Low Alloy Steels (51XX), H & T	208	114
Nitriding Steels, H & T	202	90
Low Alloy Steels (43XX), H & T	200	154
Low Alloy Steels (86XX, 87XX), H & T	194	98
High Temperature Steels, H & T	186	117
Tungsten, CW	180	160
Low Alloy Steels (61XX), H & T	179	94
Low Alloy Steels (cast)	170	45
Stainless Steels (cast), H & T	165	67
Low Alloy Steels (46XX), H & T	160	75
Titanium & Its Alloys, Ann.	160	40
Nickel-Base Superalloys, Sol'n Tr & Aged	154	92
Beryllium-Copper, Hard	150	130
Carbon Steels, H & T	142	86
Cr-Ni-Fe Superalloys, Sol'n Tr & Aged	142	71
Austenitic Stainless Steels, CW	140	75
Molybdenum, CW	130	120
Nodular Irons	125	45
Nickel-Base Superalloys (cast)	120	105
Nickel & Its Alloys, Ann. & Age Hard	120	90
Low Alloy Steels (13XX), H & T	118	100
Cobalt-Base Superalloys, Sol'n Tr & Aged	113	67
Martensitic Stainless Steels, Ann.	105	25
Free-Cutting Steels, CD	100	60
Low Alloy Steels (25XX), H & T	100	94
Pearlitic Malleable Irons	100	45
Zirconium & Its Alloys, CW	98	58
Hafnium, CW	96	—
Heat Resistant Nodular Irons	95	45
Tantalum, CW	95	90
Cr-Ni-Co-Fe Superalloys, Sol'n Tr & Aged	91	58
Nickel Silvers, Hard	90	74
Yellow Brasses (cast), High Strength	90	25
Silicon Bronzes, Hard	88	50
Stainless Steels (cast)	85	31
Carbon Steels, HR	84	29
Heat Resistant Alloys (cast), Ht Tr	81	43
Ferritic Stainless Steels, CW	80	45
Carbon Steels, CW	79	33
Aluminum & Its Alloys, Sol'n Tr & Aged	78	31
Phosphor Bronzes, Hard	75	50
Columbium, CW	75	65
Zirconium Copper, Hard	75	48
Cupro-Nickels, Hard	73	—
Nickel-Base Superalloys, Sol'n Tr	72	52
Aluminum Bronzes (cast), Ht Tr	70	40
Carbon Steels (cast)	70	30
Low Expansion Nickel Alloys, CW	70	—
Ingot Iron, CD	69	—
Nickel & Its Alloys, Ann.	65	12
Cartridge Brass, 70%, Hard	63	—
Zirconium and Its Alloys, Ann.	61	29
Tin & Aluminum Brasses, Half Hard	60	53
Leaded Brasses, Hard	60	52
Manganese Bronze (A), Half Hard	60	—
Silicon Bronzes, Ann.	60	15

Material ↓	High	Low
Yellow Brass, Hard	60	—
Low Brass, 80%, Hard	59	—
Red Brass, 85%, Hard	57	—
Austenitic Stainless Steels, Ann.	55	30
Beryllium, Ann.	55	45
Chromium Copper, Hard	55	—
Ferritic Stainless Steels, Ann.	55	35
Commercial Bronze, 90%, Hard	54	—
Naval Brass, Half Hard	53	—
Free-Cutting Brass, Half Hard	52	—
Aluminum & Its Alloys, Hard	50	22
Gilding, 95%, Hard	50	—
Leaded Commercial Bronze, Half Hard	50	—
Sulfur Copper, Half Hard	48	—
Aluminum Bronzes (cast)	45	27
Copper, Hard	45	—
Thorium, CW	45	—
Magnesium Alloys	44	19
Silver, CW	44	—
Tellurium Copper, Half Hard	44	—
Cobalt (cast)	43	20
Aluminum & Its Alloys (cast), Sol'n Tr & Aged	42	20
Low Expansion Nickel Alloys, Ann.	40	33
Nickel Brasses & Bronzes (cast), Leaded	40	15
Standard Malleable Irons	40	32
Austenitic Nodular Irons	38	32
Beryllium-Copper, Ann.	35	25
Hafnium, Ann.	32	—
Gold, CW	30	—
Magnesium Alloys (cast)	30	8
Nickel Silvers, Ann.	30	18
Palladium, CW	30	—
Tin & Aluminum Brasses, Ann.	30	22
Phosphor Bronzes, Ann.	28	14
Platinum, CW	27	—
Wrough tIrons, HR	27	—
Aluminum & Its Alloys (cast)	26	8
Tin Bronzes (cast), Leaded	26	16
Thorium, Ann.	26	—
Uranium, Ann.	25	—
Red Brasses (cast), Leaded	24	12
Aluminum & Its Alloys, Ann.	23	4
Cupro-Nickels, Ann.	22	15
Tin Bronzes (cast), High Leaded	22	11
Muntz Metal, Ann.	21	—
Architectural Bronze (extr)	20	—
Forging Brass (extr)	20	—
Leaded Brasses, Ann.	20	17
Yellow Brasses (cast), Leaded	20	11
Ingot Iron, Ann.	19	—
Free-Cutting Brass, Ann.	18	—
Chromium Copper, Ann.	15	—
Yellow Brass, Ann.	14	—
Low Brass, 80%, Ann.	12	—
Cartridge Brass, 70%, Ann.	11	—
Commercial Bronze, 90%, Ann.	10	—
Copper, Ann.	10	—
Gilding, 95%, Ann.	10	—
Red Brass, 85%, Ann.	10	—
Silver, Ann.	8	—
Tin & Its Alloys, CR	6	2
Platinum, Ann.	5.5	—
Palladium, Ann.	5	—
Lead & Its Alloys	1.6	0.8
Tin & Its Alloys, Ann.	1.3	—

[a] Values represent high and low sides of a range of *typical* values at 0.2% offset.

Tensile Strength*

1000 psi

Material	High	Low
Ultra High Strength Steels, H & T	311	279
Rhodium, CW	300	—
Martensitic Stainless Steels, H & T	285	90
Low Alloy Steels (40XX), H & T	269	120
Low Alloy Steels (92XX), H & T	258	232
Age Hardenable Stainless Steels, Sol'n Tr & Aged	240	86
Titanium & Its Alloys, Ht Tr	240	160
High Temperature Steels, H & T	235	139
Aluminum Silicate Fibers	230	50
Low Alloy Steels (41XX), H & T	230	200
Low Alloy Steels (51XX), H & T	224	143
Glass Fibers	220	200
Low Alloy Steels (43XX), H & T	220	180
Stainless Steels (cast), H & T	220	110
Low Alloy Steels (86XX, 87XX), H & T	214	122
Nitriding Steels, H & T	206	121
Nickel-Base Superalloys, Sol'n Tr & Aged	205	162
Low Alloy Steels (cast)	200	70
Tungsten, CW	200	180
Cr-Ni-Fe Superalloys, Sol'n Tr & Aged	196	114
Nickel & Its Alloys, Ann. & Age Hard	190	130
Carbon Steels, H & T	189	113
Low Alloy Steels (61XX), H & T	187	125
Austenitic Stainless Steels, CW	185	110
Beryllium-Copper, Hard	185	165
Low Alloy Steels (46XX), H & T	185	100
Titanium & Its Alloys, Ann.	170	110
Tungsten, Str Rel	170	150
Cobalt-Base Superalloys, Sol'n Tr & Aged	165	101
Cellulosic Fibers	155	20
Cr-Ni-Co-Fe Superalloys, Sol'n Tr & Aged	154	118
Nodular Irons	150	60
Nickel & Its Alloys (cast), Ann. & Aged	145	30
Tungsten-Titanium Carbide Cermet	145	118
Molybdenum, CW	145	135
Carbon Steels, HR	142	51
Low Expansion Nickel Alloys, CW	140	90
Low Alloy Steels (13XX), H & T	137	122
Titanium Carbide Cermet	134	26
Bast Fibers	132	57
Nickel-Base Superalloys, Sol'n Tr	131	114
Nickel-Base Superalloys (cast)	130	117
Phosphor Bronzes, Hard	130	65
Tungsten Carbide Cermet	130	—
Nylon Fiber	128	59
Polyester Fibers	126	67
Hard Fibers	125	100
Martensitic Stainless Steels, Ann.	125	65
Low Alloy Steels (25XX), H & T	120	113
Nickel & Its Alloys, Ann.	120	50
Pearlitic Malleable Irons	120	65
Yellow Brasses (cast), High Strength	120	60
Aluminum Bronzes (cast), Ht Tr	115	90
Austenitic Stainless Steels, Ann.	115	80
Heat Resistant Alloys (cast), Ht Tr	115	73
Molybdenum, Str Rel	115	105
Vanadium & Hafnium, CW	113	112
Free-Cutting Steels, CD	110	70
Heat Resistant Steels (cast)	110	65
Cotton Fiber	109	44
Vanadium, CW	109	—
Zirconium & Its Alloys, CW	108	82
Nickel Silvers, Hard	105	83
Stainless Steels (cast)	105	69
Asbestos Fibers	100	80
Carbon Steels (cast)	100	60
Heat Resistant Nodular Irons	100	60
Silicon Bronzes, Hard	100	70
Tantalum, CW	100	—
Aluminum Bronzes (cast)	95	75
Carbon Steels, CW	92	56
Beryllium, Ann.	90	60
Ferritic Stainless Steels, CW	90	75
Polyethylene Fibers	90	11
Silicon Bronzes, Ann.	90	40
Uranium, Ann.	90	—
Aluminum & Its Alloys, Sol'n Tr & Aged	88	35
Columbium, CW	85	75
Ferritic Stainless Steels, Ann.	85	65
Plastics Laminates, Low Pressure	85	8
Tin & Aluminum Brasses, Half Hard	84	75
Animal Fibers	83	20
Beryllium-Copper, Ann.	80	60
Cupro-Nickels, Hard & Light Drawn	80	60
Leaded Brasses, Hard	80	55
Zirconium Copper, Hard	80	56
Hafnium, Ann.	77	—
Low Expansion Nickel Alloys, Ann.	77	68
Cartridge Brass, 70%, Hard	76	—
Gray Irons	75	15
Low Brass, 80%, Hard	74	—
Yellow Brass, Hard	74	—
Ingot Iron, CD	73	—
Rhodium, Ann.	73	—
Vanadium, Ann.	72	—
Red Brass, 85%, Hard	70	—
Tantalum, Str Rel	70	60
Austenitic Nodular Irons	68	58
Free-Cutting Brass, Half Hard	68	—
Zirconium & Its Alloys, Ann.	68	49
Phosphor Bronzes, Ann.	66	40
Nickel Brasses & Bronzes (cast), Leaded	65	30
Tin & Aluminum Brasses, Ann.	65	53
Vanadium, Ann.	64	—
Nickel Silvers, Ann.	63	49
Chromium Copper, Hard	62	—
Commercial Bronze, 90%, Hard	61	—
Aluminum & Its Alloys, Hard	60	22
Architectural Bronze (extr)	60	—
Cupro-Nickels, Ann.	60	44
Leaded Brasses, Ann.	60	49
Standard Malleable Irons	60	52
Acrylic Fibers	57	26
Gilding, 95%, Hard	56	—
Copper, Hard	55	50
Leaded Commercial Bronze, Half Hard	55	—
Micas, Natural & Synthetic	55	40
Magnesium Alloys	55	34
Muntz Metal, Ann.	54	—
Silver, CW	54	—
Forging Brass (extr)	52	—
Sulfur Copper, Half Hard	50	—
Aluminum & Its Alloys (cast), Sol'n Tr & Aged	49	36
Free-Cutting Brass, Ann.	49	—
Thorium, CW	49	—
Tellurium Copper, Half Hard	48	—
Tin Bronzes (cast), Leaded	48	33
Wrought Irons, HR	48	39

* Values represent high and low sides of a range of *typical* values at room temperature.

Tensile Strength*

1000 psi

Material ↓	High	Low
Zinc & Its Alloys (cast)	4 .6	25
Fluorocarbon Fiber	47	—
Palladium, CW	47	—
Red Brasses (cast), Leaded	46	29
Yellow Brass, Ann.	46	—
Zinc & Its Alloys, CR	46	21
Aluminum & Its Alloys, Ann.	45	12
Columbium, Str Rel	45	35
Platinum, CW	45	34
Vinyl Fibers	45	12
Yellow Brasses (cast), Leaded	45	30
Cartridge Brass, 70%, Ann.	44	—
Aluminum & Its Alloys (cast)	43	19
Ingot Iron, Ann.	42	—
Low Brass, 80%, Ann.	42	—
Zinc & Its Alloys, HR	42	19.5
Magnesium Alloys (cast)	40	23
Vinylidene Chloride	40	4
Alumina Ceramics	39	20
Red Brass, 85%, Ann.	39	—
Tin Bronze (cast), High Leaded	38	25
Chromium Carbide Cermet	37	36
Commercial Bronze, 90%, Ann.	37	—
Plastic Laminates, High Pressure	37	7
Chromium Copper, Ann.	35	—
Copper, Ann.	35	32
Cobalt (cast)	34.4	—
Gilding, 95%, Ann.	34	—
Thorium, Ann.	34	—
Gold, CW	32	—
Nylon, Glass-Filled	31	19
Palladium, Ann.	30	—
Polyester Film	28	17
Platinum, Ann.	26	17
Silicon Carbide	25	3
Boron Carbide	22.5	—
Silver, Ann.	22	—
Alumina Cermets	21	—
Cellophane	19	7
Gold, Ann.	19	—
Nylon 6 Film	17	13.8
Polystyrenes, Glass-Filled	17	11
Epoxies (molded)	16	5
Polyvinylidene Chloride Film	15	7
Steatite	15	4.8
Nylon 66 & 610	12.6	7.1
Epoxies (cast)	12	0.1
Nylon 6 & 11	12	8.5
Polystyrene Film	12	7
Zircon	12	4.5
Tin-Lead-Antimony Alloys (cast)	11.8	6.8
Modified Polystyrenes	11	3
Polyvinyl Formal	11	9
Acrylics (molded, extr)	10.5	5.5
Polycarbonate	10.5	9
Acetal	10	—
Alkyds, Impact	10	6
Ethyl Cellulose Film	10	6
Forsterite	10	—
Melamines, Phenolics (molded)	10	3.5
Polyesters (cast)	10	0.9
Polypropylene Film	10	5
Polyvinyl Alcohol Film	10	6
Ureas	10	5
Hard Rubber	9.3	2
Methylstyrenes	9.3	6.6
Phenolics (cast)	9	2.5
Polyvinyl Chloride	9	1

Material ↓	High	Low
Tin & Its Alloys, CR	8.7	2.8
Tin & Its Alloys, Ann.	8.6	2.2
ABS Resins	8.5	3
Cellulose Acetate	8.5	1.9
Polyvinyl Butyral	8.5	4
Polyvinyl Chloride Film, Rigid	8.5	6.5
Acrylics (cast), GP	8	6
Cellulose Nitrate	8	7
Polyethylene Film	8	1.6
Polystyrenes, GP	8	5
Wood Comp Board (par. to sur), Hardboard	7.8	3
Cellulose Propionate	7.5	1.5
Lead & Its Alloys (cast)	7.4	2
Acrylics, High Impact	7.3	5.5
Diallyl Phthalate	7	4
Electrical Ceramics	7	2.5
Ethyl Cellulose	7	3
Mica, Glass-Bonded	7	5
Cellulose Acetate Butyrate	6.8	1.9
CFE Film	6.6	6.3
Chlorinated Polyether	6	—
Rubber Hydrochloride Film	6	5
Urethane Rubber (gum)	>5	—
CFE Fluorocarbons	5.7	4.6
Polyprophylene	5	—
Polyvinyl Alcohol	5	1
Polyvinyl Chloride Film, Nonrigid	5	1
Silicones (molded)	5	4
Wood Comp Board (par. to sur), Particle	5	0.5
Lead & Its Alloys (rolled)	4.7	2.4
Natural Rubber (black)	4.5	3.5
Nitrile Rubber (black)	4.5	3
Polythylene, High Density	4.4	2.9
Alkyds, GP & Elec.	4	3
Neoprene Rubber (black)	4	3
PVC-Nitrile Rubber Blend Film	4	1.5
Styrene-Butadiene Rubber (black)	3.5	2.5
TFE Fluorocarbons	3.5	2.5
Lead & Its Alloys (extr)	3.3	2
Butyl Rubber (black)	3	2.5
Cordierite	3	—
TFE Film	3	2
Polyethylene, Medium Density	2.4	2
Viton Rubber (gum)	>2	—
Graphite	2	0.4
Wood Comp Board (par. to sur), Softboard	2	0.2
Fluorinated Acrylic Rubber (gum)	1.2	—
Urethane Foamed-in-Place, Rigid	1.2	0.010
Carbon	1.1	0.9
Polysulfide Rubber (gum)	>1	—
Silicone Rubber (gum)	1	0.6
Polyethylene, Low Density	0.9	2.5
Wool Felts, Sheet	0.8	0.4
Polyethylene Foam, Flexible	0.67	—
Prefoamed Epoxy, Rigid	0.65	0.05
Wool Felts, Roll	0.6	0.08
Vinyl Foams, Flexible	0.2	0.01
Prefoamed Polystyrene, Rigid	0.19	0.030
Prefoamed Cellulose Acetate, Rigid	0.18	0.11
Polystyrene Foamed-in-Place, Rigid	0.13	0.030
Neoprene Foams	0.1	0.02
Butadiene-Styrene Foams	0.08	—
Phenolic Foamed-in-Place, Rigid	0.075	0.004
Butadiene-Acrylonitrile Foams	0.04	—
Natural Rubber Foam	0.020	0.010

* Values represent high and low sides of a range of *typical* values at room temperature.

Elongation*

Percent

Material	High	Low
Butyl Rubber (black)	850	650
Polyethylene Film	800	50
Urethane Rubber (gum)	750	540
Polyethylene, Low Density	725	80
Polypropylene	700	500
Natural Rubber (black)	650	550
Nitrile Rubber (black)	650	450
Polysulfide Rubber (gum)	650	450
Neoprene Rubber (black)	600	500
Polyvinyl Alcohol	600	300
Styrene-Butadiene Rubber (black)	600	500
Polyvinyl Chloride Film, Nonrigid	500	50
PVC-Nitrile Rubber Blend Film	500	250
Rubber Hydrochloride Film	500	350
Polyvinyl Chloride	450	5
Polyethylene, Medium Density	425	200
Polyethylene, High Density	400	12
Silicone Rubber (gum)	400	60
Natural Rubber Foam	380	—
Viton Rubber (gum)	>350	—
TFE Fluorocarbons	350	250
Nylon 66 & 610	320	60
Polyesters (cast), Nonrigid	310	30
Polyethylene Foam, Flexible	310	—
Fluorinated Acrylic Rubber (gum)	300	—
Nylon 6 & 11	300	100
Vinyl Foams, Flexible	300	75
Polyvinyl Butyral	250	50
TFE Film	250	200
Nylon 6 Film	>200	—
Polypropylene Film	>200	—
ABS Resins	200	5
CFE Film	200	90
CFE Fluorocarbons	175	125
Epoxies (cast)	150	2
Chlorinated Polyether	130	60
Polyester Film	130	70
Vinyl Fibers	120	15
Polycarbonate	100	60
Polyethylene Fibers	80	—
Lead & Its Alloys (extr)	75	48
Cellulose Acetate Butyrate	74	38
Cellulose Acetate	70	6
Cellulosic Films	70	15
Phosphor Bronzes, Ann.	70	48
White Metal, Ann.	70	—
Cartridge Brass, 70%, Ann.	66	—
Admiralty Brass, Ann.	65	—
Yellow Brass, Ann.	65	—
Zinc & Its Alloys, HR	65	10
Cobalt-Base Superalloys, Sol'n Tr & Aged	64	2
Nickel-Base Superalloys, Sol'n Tr & Aged	63	14
Silicon Bronzes, Ann.	63	20
Titanium Carbide Cermet	61	0
Austenitic Stainless Steels, Ann.	60	45
Austenitic Stainless Steels, CW	60	8
Polyvinyl Formal	60	5
Cellulose Propionate	60	50
Nickel & Its Alloys, Ann.	60	25
Hard Lead (rolled)	60	16
Zinc & Its Alloys, CR	60	10
Soft Leads (rolled)	57	43
Grade A Tin (cast)	55	—
Leaded Brasses, Ann.	55	30
Stainless Steels (cast)	55	15
Free-Cutting Brass, Ann.	53	—
Low Brass, 80%, Ann.	52	—
Magnesium Alloys (cast), Sol'n Tr & Aged	51	—
Thorium, Ann.	51	—
Beryllium-Copper, Ann.	50	35
Cellophane	50	15
Monel, Ann.	50	24
Nickel-Base Superalloys, Sol'n Tr	50	43
Nickel Silvers, Ann.	50	32
Pewter, CR	50	—
Zinc Alloys, HR	50	10
Zinc, CR	50	30
Cr-Ni-Co-Fe Superalloys, Sol'n Tr & Aged	49	3
Low Expansion Nickel Alloys, Ann.	49	43
Monel (cast)	49	1
Ingot Iron, Ann.	48	—
Red Brass, 85%, Ann.	48	—
Silver, Ann.	48	—
Naval Brass, Ann.	47	—
Soft Leads (chill cast)	47	39
Age Hardenable Stainless Steels, Sol'n Tr & Aged	45	3
Aluminum & Its Alloys, Ann.	45	17
Commercial Bronze, 90%, Ann.	45	—
Copper, Ann.	45	35
Cupro-Nickels, Ann.	45	27
Cupro-Nickels, Light Drawn	45	42
Forging Brass (extr)	45	—
Gilding, 95%, Ann.	45	—
Gold, Ann.	45	—
Grade A Tin, Ann.	45	—
Modified Polystyrenes	45	1
Muntz Metal, Ann.	45	—
Nickel & Its Alloys (cast)	45	1
Acrylic Fibers	42	20
Nylon Fiber	42	16
Sulfur Copper, Ann.	42	—
Cr-Ni-Fe Superalloys, Sol'n Tr & Aged	41	16
Austenitic Nodular Irons	40	7
Chromium Copper, Ann.	40	—
Palladium, Ann.	40	24
Pewter, Ann.	40	—
Platinum, Ann.	40	30
Polyvinylidene Chloride Film	40	25
Silicon Bronzes, Hard	40	15
Tantalum, Str Rel	40	11
Tin Bronzes (cast), Leaded	40	15
Tin Foil, CR	40	—
Yellow Brasses (cast), Leaded	40	15
Carbon Steels, HR	39	9
Wool Felts (at 100 psi), Roll	39	8
Polyester Fibers	36	9
Aluminum Bronzes (cast)	35	7
Animal Fibers	35	13
Carbon Steels, CW	35	20
Ethyl Cellulose Film	35	20
Grade A Tin, CR	35	—
Heat Resistant Alloys (cast)	35	4
Martensitic Stainless Steels, Ann.	35	14
Red Brasses (cast), Leaded	35	15
Yellow Brasses (cast), High Strength	35	12

* Values represent high and low sides of a range of *typical* values at room temperature.

Elongation[a]

Percent

Material ↓	High	Low
Cellulosic Fibers	34	6
Hard Rubber	33	1
Manganese Bronze (A), Ann.	33	—
Carbon Steels (cast)	32	20
Architectural Bronze (extr)	30	—
Cobalt (cast)	30	4
Columbium, Str Rel	30	—
Ferritic Stainless Steels, Ann.	30	20
Martensitic Stainless Steels, H & T	30	2
Nickel Brasses & Bronzes (cast), Leaded	30	10
Soft Leads (sand cast)	30	—
Stainless Steels (cast), H & T	30	1
Vinylidene Chloride	30	15
Vanadium, Ann.	28	—
White Metal, CR	28	—
Wool Felts (at 100 psi), Sheet	28	2
Zinc Alloys, CR	28	—
Zirconium & Its Alloys, Ann.	27	22
Low Alloy Steels (cast)	26	5
Acrylics (molded, extr)	>25	3
Ferritic Stainless Steels, CW	25	15
High Alloy Steels (cast), Ht Tr	25	4
Low Alloy Steels (25XX), H & T	25	22
Malleable Irons	25	2
Nickel & Its Alloys, Ann. & Age Hard	25	10
Nodular Irons	25	2
Polypropylene Fiber	25	12
Polyvinyl Chloride Film, Rigid	25	5
Standard Malleable Irons	25	10
Titanium & Its Alloys, Ann.	25	10
Zirconium Copper, Hard	25	5
Hafnium, Ann.	24	—
Hard Lead Alloys (chill cast)	24	16
Monel, Ann. & Age H	24	14
Carbon Steels, H & T	23	11
Nitriding Steels, H & T	23	15
Aluminum & Its Alloys, Sol'n Tr & Aged	22	11
Free-Cutting Steels, CD	22	10
Tin-Base Babbitts (die cast)	22	4
Low Alloy Steels (61XX), H & T	21	13
Low Alloys Steels (86XX, 87XX), H & T	21	12
Columbium, CW	20	15
Heat Resistant Nodular Irons	20	0
Low Alloy Steels (13XX), H & T	20	19
Low Expansion Nickel Alloys, CW	20	—
Molybdenum, Str Rel	20	15
Naval Brass, Half Hard	20	—
Tin Bronzes (cast), High Leaded	20	7
Inconel (cast)	19	1
Manganese Bronze (A), Half Hard	19	—
Magnesium Alloys (cast)	19	3
Ultra High Str Steels, H & T	19	5.5
Free-Cutting Brass, Half Hard	18	—
Leaded Brasses, Hard	18	6
Low Alloy Steels (46XX), H & T	18	14
Low Alloy Steels (48XX), H & T	18	13
High Temperature Steels, H & T	16.5	8
Low Alloy Steels (41XX), H & T	16	10
Pearlitic Malleable Irons	16	2
Acetal	15	—
Aluminum Bronzes (cast), Ht Tr	15	5
Aluminum & Its Alloys, Hard	15	1.5
Low Alloy Steels (43XX), H & T	15	12
Magnesium Alloys (forged)	15	7
Tantalum, CW	15	10
Molybdenum, CW	15	5
Wrought Irons, HR	14	2
Fluorocarbon Fiber	13	—
Low Alloy Steels (51XX), H & T	13	—
Phosphor Bronzes, Hard	13	8
Uranium, Ann.	13	—
Beryllium-Copper, Hard	12	3
Chromium Copper, Hard	12	—
Ingot Iron, CD	12	—
Leaded Commercial Bronze, Half Hard	12	—
Low Alloy Steels (40XX), H & T	12	8
Magnesium Alloys (cast), Sol'n Tr	12	10
Sulfur Copper, Half Hard	12	—
Tellurium Copper, Half Hard	12	—
Titanium & Its Alloys, Ht Tr	12	3
Aluminum & Its Alloys (cast), Sol'n Tr & Aged	10	0.5
Hafnium, CW	10	—
Low Alloy Steels (92XX), H & T	10	9
Polystyrene Film	10	3
Zinc & Its Alloys (cast)	10	1
Zirconium & Its Alloys, CW	10	1.5
Copper, Hard	10	1.5
Monel, Age H	10	5
Aluminum & Its Alloys (cast)	9	2
Cartridge Brass, 70%, Hard	8	—
Yellow Brass, Hard	8	—
Hard Fibers	7.5	1
Low Brass, 80%, Hard	7	—
Cotton Fiber	7	3
Acrylics (cast), GP	7	2
Nickel-Base Superalloys (cast)	6	5
Bast Fibers	6	3
Cupro-Nickels, Hard	6	—
Beryllium, Ann.	5	2
Commercial Bronze, 90%, Hard	5	—
Gilding, 95%, Hard	5	—
Nickel Silvers, Hard	5	3
Methylstyrenes	5	2.5
Polyesters (cast), Rigid	5	—
Red Brass, 85%, Hard	5	—
Gold, CW	4	—
Hard Rubber, GP	4	2
Nickel & Its Alloys (cast), Ann. & Aged	4	1
Phosphor Bronzes, Spring	4	3
Glass Fibers	3.8	2
Platinum, CW	3.5	2.5
Vanadium, CW	3	—
Aluminum Silicate Fibers	2.7	1.4
Hard Rubber, Chem & High Ht Res	2.6	—
Silver, CW	2.5	—
Polystyrenes, GP	2.4	1.5
Nylon, Glass-Filled	2.3	1.5
Phenolics (molded)	2.25	0.10
Palladium, CW	1.5	—
Polystyrenes, Glass-Filled	1.3	1.1
Ureas	1	—
Melamines	0.8	0.3
Cobalt	0.4	—
Chromium Carbide Cermet	0	—
Tungsten, CW	0	—

[a] Values represent high and low sides of a range of *typical* values at room temperature.

Hardness of Metals[a]

Brinell

Material ↓	High	Low	Material ↓	High	Low
Martensitic Stainless Steels, H & T	580	180	Yellow Brass, Hard	160	--
Low Alloy Steels (40XX), H & T	534	415	Rhodium, Ann.	156	55
Low Alloy Steels (92XX), H & T	514	477	Standard Malleable Irons	156	110
Stainless Steels (cast), H & T	470	185	Cartridge Brass, 70%, Hard	154	—
Low Alloy Steels (43XX), H & T	445	360	Muntz Metal, Hard	151	—
Low Alloy Steels (61XX), H & T	444	429	Aluminum & Its Alloys, Sol'n Tr & Aged	150	73
Low Alloy Steels (51XX), H & T	444	302	Naval Brass, Hard	150	130
Low Alloy Steels (41XX), H & T	444	375	Nickel Brasses & Bronzes (cast), Leaded	150	50
Low Alloy Steels (86XX, 87XX), H & T	423	245	Standard Malleable Irons	147	103
Nitriding Steels, H & T	415	230	Low Expansion Nickel Alloys, Ann.	144	132
Low Alloy Steels (cast)	400	150	Ingot Iron, CD	142	—
High Carbon Steels, H & T	390	310	Low Carbon Steels, HR	141	119
Low Alloy Steels (46XX), H & T	390	—	Yellow Brass, Hard	140	—
Rhodium, CW	390	260	Cobalt, Ann.	138	122
Duranickel, Age H	380	300	Cobalt (cast)	135	105
Low Alloy Steels (48XX), H & T	380	325	Low Brass, 80%, Hard	130	—
Nickel & Its Alloys (cast)	380	80	Red Brass, 85%, Hard	126	—
Nickel & Its Alloys (cast), Ann. & Aged	380	300	Palladium, CW	109	—
Iridium, CW	350	—	Commercial Bronze, 90%, Hard	107	—
Monel, Age H	350	290	Aluminum & Its Alloys, Hard	105	44
Osmium (cast)	350	—	Gilding, 95%, Hard	105	—
Nodular Irons	325	140	Wrought Irons, HR	105	97
Gray Irons	300	170	Platinum, CW	97	13
Heat Resistant Nodular Irons	300	140	Zinc Alloys (die cast)	90	82
High Carbon Steels, HR	289	231	Aluminum & Its Alloys (cast)	85	40
Low Alloy Steels (13XX), H & T	285	248	Magnesium Alloys (cast), Sol'n Tr & Aged	84	73
Pearlitic Malleable Irons	285	160	Muntz Metal, Ann.	82	—
Nickel Steels, CD	272	188	Zinc Alloys, CR	80	60
Heat Resistant Alloys (cast), Ht Tr	270	185	Tin Bronzes (cast), Leaded	80	60
Martensitic Stainless Steels, Ann.	260	150	Aluminum & Its Alloys, Ann.	75	23
Low Alloy Steels (25XX), H & T	244	233	Yellow Brasses (cast), Leaded	75	40
Nickel-Base Superalloys, Sol'n Tr	241	187	Tin Bronzes (cast), High Leaded	70	35
Austenitic Stainless Steels, CW	240	—	Ingot Iron, Ann.	69	—
Aluminum Bronzes (cast), Ht Tr	235	180	Magnesium Alloys (forged)	69	47
Free-Cutting Steels, CD	230	150	Magnesium Alloys (cast)	65	50
Nickel Steels, HR	225	155	Red Brasses (cast), Leaded	65	50
Yellow Brasses (cast), High Strength	225	80	Magnesium Alloys (cast), Sol'n Tr	63	51
Heat Resistant Alloys (cast)	223	160	Zinc Alloys, HR	61	51
Manganese Steels, Ann.	222	178	Gold, CW	58	—
Ruthenium (cast)	220	—	Platinum, Ann.	52	38
Yellow Brass (cast), High Strength	220	80	Zinc, HR	47	37
Medium Carbon Steels, CW	219	181	Palladium, Ann.	46	—
Medium Carbon Steels, HR	214	166	Copper, Ann.	40	—
Medium Carbon Steels, H & T	213	207	Silver, Ann.	35	25
Stainless Steels (cast), Ann.	210	195	Lead-Base Babbitts (chill cast)	28	14
High Carbon Steels, Ann.	208	192	Tin-Base Babbitts (chill cast)	27	17
Austenitic Nodular Irons	200	140	Gold, Ann.	25	—
Carbon Steels (cast)	200	120	Pewter (cast)	23	—
Aluminum Bronzes (cast)	195	120	White Metal (cast)	20	—
Copper, Hard	194	—	White Metal, Ann.	17	—
Ferritic Stainless Steels, CW	185	—	Hard Lead Alloys (chill cast)	15.4	7
Austenitic Stainless Steels, Ann.	170	150	Pewter, Ann.	13	—
Iridium, Ann.	170	—	Lead & Its Alloys (extr)	12.4	5.1
Low Carbon Steels, CW	165	120	Hard Lead Alloys (rolled)	9.5	5.9
Manganese Bronze, Half Hard	160	—	Grade A Tin, Ann.	7	—
Aluminum & Its Alloys (cast), Sol'n Tr & Aged	160	80	Soft Lead (chill cast)	4.2	—

[a] Values represent high and low sides of a range of *typical* values.

Hardness of Plastics and Rubber[a]

Material	High	Low
ROCKWELL M HARDNESS		
Melamines	M125	M110
Phenolics, Elec	M120	M100
Phenolics (cast), Mech & Chem	M120	M92
Phenolics, GP	M120	M108
Phenolics, Shock & Ht Res	M120	M92
Plastics Laminates, High Pressure	M120	M70
Plastics Laminates, Low Pressure	M120	M80
Ureas	M120	M116
Allyls (cast)	M118	M92
Polyesters (cast), Rigid	M115	M65
Epoxies (cast)	M110	M76
Epoxies (molded)	M110	—
Diallyl Phthalate	M108	M100
Acrylics	M103	M80
Nylons, Glass Fiber-Filled	M95	M85
Polyvinyl Formal	M90	M80
Polystyrene, Glass Fiber-Filled	M90	M80
Rubber Phenolics	M90	M40
Silicones (molded), GP	M89	—
Modified Polystyrenes, Ht & Chem Res	M88	M78
Polymethylstyrene	M86	M76
Methylstyrene-Acrylonitrile	M83	—
Modified Polystyrenes, Impact Res	M80	M15
Polystyrenes, GP	M80	M68
Vinylidene Chloride	M65	M50
Silicones (molded), Impact Res	M45	—

Material	High	Low
ROCKWELL R HARDNESS		
Cellulose Acetate	R121	R39
Acetal	R120	—
Cellulose Propionate	R120	R20
Ethyl Cellulose	R120	R70
ABS Resins	R118	R30
Nylon 6, 11, 66, & 610	R118	R103
Polycarbonate	R118	—
Cellulose Nitrate	R115	R95
CFE Fluorocarbons	R115	R110
Cellulose Acetate Butyrate	R114	R59
Diallyl Phthalate	R108	R107
Chlorinated Polyether	R100	—
Polystyrenes, Glass-Filled	R100	R90
Polypropylene	R95	R85
DUROMETER A HARDNESS		
Hard Rubber	A95	A50
Neoprene & Nitrile Rubber	A95	A40
Butyl Rubber	A90	A40
Natural Rubber	A90	A30
Styrene-Butadiene Rubber	A90	A40
Viton Rubber	A90	A60
Polysulfide Rubber	A85	A40
Silicone Rubber	A85	A40
Fluorinated Acrylic Rubber	A55	—
Urethane Rubber	A55	—

[a] Values represent high and low sides of a range of *typical* values; no relationship between different scales is implied.

Hardness of Nonmetallics (exc Plastics & Rubber)[a]

Knoop

Material	High	Low
Cubic Boron Nitride	7000	—
Diamond	7000	—
Boron Carbide	2800	—
Titanium Boride	2720	—
Silicon Carbide	2500	—
Titanium Carbide	2460	—
Beryllium Carbide	2300	—
Zirconium Carbide	2090	—
Tantalum Carbide	2050	—
Columbium Carbide	1880	—
Tungsten Carbide	1880	—
Cemented Carbides	1800	1400
High Alumina Ceramics	1750	1450

Material	High	Low
Zirconium Boride	1560	—
Chromium Carbide	1300	—
Beryllia	1220	—
Molybdenum Disilicide	1065	850
Quartz	800	—
Polycrystalline Glass	703	698
Glasses	500	300
Mica, Synthetic	200	—
Calcite	130	—
Mica, Natural	90	—
Gypsum	30	—
Forsterite	7.5	—
Cordierite	7	—

[a] Values represent high and low sides of a range of *typical* values.

Impact Strength of Metals[a]

Notched Izod, ft-lb

Material	High	Low	Material	High	Low
Austenitic Stainless Steels, Ann.	165	80	Low Alloy Steels (61XX), H & T	28	13
Austenitic Stainless Steels, CW	90	—	Ferritic Stainless Steels, Ann.	25	2
Martensitic Stainless Steels, Ann.	90	2	Low Alloy Steels (41XX), H & T	25	12
Low Alloy Steels (25XX), H & T	85	80	High Carbon Steels, H & T	22	5
Nitriding Steels, H & T	80	65	White Metal (cast)	22	—
Low Alloy Steels (86XX, 87XX), H & T	76	18	Carbon Steels (cast), Norm. & T	20	—
Martensitic Stainless Steels, H & T	75	2	High Carbon Steels, HR	18	4
Low Alloy Steels (46XX), H & T	68	25	Low Alloy Steels (51XX), H & T	16	6
Nickel-Base Superalloys	62	21	Tin Bronzes (cast), Leaded	16	7
Silicon Bronzes, Ann.	45	42	Tin (cast)	14	—
Low Alloy Steels (48XX), H & T	44	28	Low Alloy Steels (92XX), H & T	12	6
Yellow Brasses (cast), High Strength	40	7	Red Brasses (cast), Leaded	12	6
Low Alloy Steels (43XX), H & T	32	16	Tin Bronzes (cast), High Leaded	8	2
Cobalt-Base Superalloys, Sol'n Tr & Aged	31	4	Magnesium Alloys, Sol'n Tr	5	4
Carbon Steels (cast), Ann.	30	—	Magnesium Alloys (forged)	5	3
			Tin-Lead-Antimony Alloys (cast)	2.5	1
			Magnesium Alloys (cast), Sol'n Tr	2	1

[a] Values represent high and low sides of a range of *typical* values. Values in this table are not directly comparable to those for Plastics (below) because the methods of computing test results differ.

Impact Strength of Plastics

Notched Izod, ft-lb/in.

Material	High	Low	Material	High	Low
Phenolics (molded), Very High Shock	33	10	Modified Polystyrenes, High Impact	3	1
Epoxies (molded)	30	0.2	Plastics Laminates, Mech	3	0.2
Silicones, High Impact	20	15	Cellulose Acetate, Hard	2.7	0.4
Plastics Laminates, Low Pressure	18	7	Prefoamed Polystyrene, Rigid	2.7	0.5
Nylon, Soluble	>16	—	Rubber Phenolics	2.3	0.3
Polycarbonate	16	12	Nylon 66 & 610	2	0.6
Plastics Laminates, GP	14.4	1	Polyvinyl Formal	2	0.4
Plastics Laminates, Elec	14	6	Epoxies (cast), Ht Res	1.5	0.2
Polyethylenes, High Density	14	0.4	Melamines, Shock Res	1.5	0.5
Alkyds, Impact	12	8	Acetal	1.4	—
Melamines, Glass Fiber-Filled	12	4	Diallyl Phthalate, Orlon-Filled	1.2	0.5
Cellulose Propionate	11	0.8	Polyvinyl Chloride	1.2	0.25
Modified Polystyrenes, Extra High Impact	11	6	Polypropylene	1.02	—
ABS Resins, Low Temp Impact	10	6	Polyvinyl Butyral	1.02	0.74
ABS Resins, Extra High Impact	9	5	Acrylics (molded, extr)	0.8	0.2
Vinylidene Chloride	8	2	Epoxies (cast), GP	0.7	0.2
Polyesters (cast), Nonrigid	>7	—	Acrylics (cast)	0.5	0.4
Cellulose Nitrate	7	5	Phenolics (molded), GP	0.50	0.24
Epoxies (cast), Resilient	7	0.5	Diallyl Phthalate, Asbestos-Filled	0.45	0.30
Ethyl Cellulose, High Impact	7	3.6	Phenolics (cast)	0.45	0.23
Polystyrenes, Glass-Filled	6.1	4.1	Chlorinated Polyether	0.4	—
ABS Resins, High Impact	6	0.5	Melamines, Elec	0.40	0.28
Diallyl Phthalate, Glass Fiber-Filled	6	0.5	Methylstyrene-Acrylonitrile	0.40	—
Ethyl Cellulose, GP	6	1.8	Modified Polystyrenes, Ht & Chem Res	0.4	0.26
Cellulose Acetate Butyrate	5.4	0.6	Polyesters (cast), Rigid	0.40	0.18
Cellulose Acetate, Soft	5.2	1.7	Alkyds, GP & Elec	0.35	0.30
Nylon, Glass-Filled	5	2.5	Melamines, GP	0.35	0.24
Diallyl Phthalate, Dacron-Filled	4.5	1.7	Polystyrenes, GP	0.35	0.25
Cellulose Acetate, Medium	4	1.1	Ureas	0.35	0.24
TFE & CFE Fluorocarbons	4	2.5	Allyls (cast)	0.32	0.18
Nylon 6	3.6	1.2	Silicones, GP	0.30	0.25
Phenolics (molded), Heat & Shock	3.5	0.27	Vinylidene Chloride, Oriented	0.05	—

Creep Strength of Metals

Material	Form, Condition	Stress (1000 psi) for 0.01% Creep per 1000 Hr at Indicated Temp (F)					Stress (1000 psi) for 0.1% Creep per 1000 Hr at Indicated Temp (F)				
Up to 800 F		300	400	500	600	800	300	400	500	600	800
NONFERROUS METALS											
Coppers	Wrought (annealed)	3–8	1.5–5	0.4–2.6	—	—	—	—	—	—	—
Nonleaded Brasses	Wrought (annealed)	0.9–19	2–11	0.3–23	—	—	25	5–9	1–2	—	—
Bronzes	Wrought (annealed)	14–23	5–10	2–5	—	—	—	—	—	—	—
Cupro-Nickel	Wrought (water quenched, aged)	25–40	15–30	8–30	—	—	—	22	13	—	—
Aluminum 2024-T	Sheet	23	9.5	2.5	1.5	—	30	13	3	2	—
Aluminum 7075-T	Sheet	12	4	2.5	1.5	—	16	6	3	2	—
Titanium (commercial)	Sheet (annealed)	—	38	—	32	10	37	40	37	32	13
Ti-6Al-4V	Sheet (annealed)	—	—	—	—	—	—	—	—	80	—
Ti-7Al-4Mo	Bar or Forging (annealed)	—	—	—	—	—	—	—	—	85	18
Above 800 F		1000	1100	1200	1500	1600	1000	1100	1200	1500	1600
CARBON AND LOW ALLOY STEELS											
Low Carbon Steel	Wrought, Cast	1.8	—	0.1	—	—	3.3–5	—	0.5	—	—
Carbon-Molybdenum Steels	Wrought, Cast	5–7	3	1	—	—	10–12	4	2	—	—
Chromium-Molybdenum Steels (0.5–3%)	Wrought, Cast	6–12	2–4	1–2.5	—	—	10–20	3–8	2–4.5	—	—
Chromium Steels 4–6%	Wrought, Cast	6–7	2.5–3.5	1–2	—	—	8–11	5–6.5	2–3.5	—	—
Chromium Steels 6–10%	Wrought, Cast	5–9	2.5–4	1–2	—	—	8–12	4–6	2.5–3	—	—
STAINLESS STEELS											
Martensitic Chromium Steels (403, 410, 416, 420)	Wrought	8	3.5	1.3	—	—	9.2	4.2	2	—	—
Ferritic Chromium Steels (405, 430, 440)	Wrought	4.2–7	2.3–4.5	1.0–1.6	—	—	6–8.5	3–5	1.5–2.2	—	—
Nickel-Chromium Steels 304, 316, 321, 347	Wrought	12–17	7.5–11.5	4.5–7	1–2	—	17–25	12–18.2	7–12.7	1.2–2.8	—
309	Wrought	—	—	4	0.5	—	15.9	11.6	8	1.0	—
310, 314	Wrought	17	13	8	2	—	17	13–14	9	1–2.5	—
HEAT RESISTANT CAST HIGH ALLOYS											
Iron-Chromium Alloys (HA, HC, HD)	Cast	—	—	—	—	—	—	—	—	1.2–3.5[a]	0.7–1.9
Iron-Chromium-Nickel Alloys (HE, HF, HH, HI, HK, HL)	Cast	—	—	—	—	—	—	—	—	3.5–7[a]	2–4.3
Nickel-Chromium Alloys (HN, HT, HU, HW, HX)	Cast	—	—	—	—	—	—	—	—	6–8.5[a]	3–5
SUPERALLOYS											
Inconel X		—	—	—	—	—	—	—	64	12.3	9.0
19-9 DL		—	—	—	—	—	—	—	20	7.1	2.4
Hastelloy X		—	—	—	—	—	—	—	—	—	—
N-155		—	—	—	—	—	—	—	18.4[b]	10.3	—
S-816		—	—	—	—	—	—	—	42	11.5	5.8

[a] At 1400 F. [b] At 1350 F.

Stress-Rupture Strength of High Temperature Alloys

10 Hr						100 Hr					
1200 F		1500 F		1800 F		1200 F		1500 F		1800 F	
Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi
Waspaloy	130	Inconel 713[a]	70	Mo-0.5 Ti[d]	65	1753	115	Nicrotung[a]	65	Mo-0.5 Ti-0.07 Zr[e]	70
M-252	120	René 41	65	Columbium[d]	53	Waspaloy	110	Inconel 713C[a]	55	Mo-0.5 Ti[e]	62
Incoloy 901[b]	110	U-500	62	Molybdenum[d]	30	Inconel 700	100	1753	47	Mo-0.5 Ti-0.07 Zr[d]	40
W-545	95	1753	60	Inconel 713[a]	24	U-212	100	René 41	45	Columbium[d]	36
Inconel X	92	Waspaloy	58	GMR-235[a, b]	16	M-252	98	Udimet 500	45	Mo-0.5 Ti[d]	28
Refractaloy 26	92	Inconel 700[b]	55	1753	16	D979	94	Inconel 700	43	Molybdenum[e]	22
S-816	83	GMR-235[a, b]	52	V-36[b, e]	13	W-545	90	Waspaloy	40	Nicrotung[a]	22
A-286	80	M-252	48	X-40[a]	13	GMR-235[a]	86	GMR-235[a]	38	Inconel 713C[a]	16
Inco 702[a, b]	75	Inconel X	38	HS-21[a]	12.5	Incoloy 901	85	M-252	37	Udimet 700	16
Hastelloy B	71.5	Refractaloy 26	36	M-252	12	Refractaloy 26	80	D-979	36	GMR-235[a]	13
Discaloy[e]	70	X-40[a]	33	HS-25	11.5	HS-25	70	S-816	29	Udimet 500	12
HS-21[a]	70	S-816	33	Inconel 700[b]	9	S-816	65	X-40[a]	29	Molybdenum[d]	11.5
Refractaloy 70	70	HS-25	30	N-155	8.8	A-286	63	S-816[a]	28	X-40[a]	11.3
Hastelloy C	69	Hastelloy B[a]	29	Hastelloy X[a]	8	Refractaloy 70	56	Refractaloy 26	27	S-816[a]	11
Nivco	66	V-36[b, e]	29	HK[a]	6.5	S-816[a]	56	HS-25	24	HS-21[a]	9.4
N-155	62	S-590	28	HH[a]	6	Discaloy	55	V-36	24	V-36	9
S-590	62	HS-21[a]	27	HT[a]	5.8	Hastelloy C	55	HS-21[a]	22	Waspaloy	8
X-40[a]	61	Hastelloy B	26	Inco 702[a, b]	4.2	Inconel 702	55	S-590	22	HS-25	7.5
Hastelloy X	58	Hastelloy C	26			Nivco	54	Incoloy 901	20	Inconel 700	5.6
16-25-6	55	N-155	26			HS-21[a]	52	N-155	20	N-155	5
N-155[a]	52	Hastelloy C[a]	25			Hastelloy B[a]	51	N-155[a]	19	HT, HK[a]	4.5
19-9DL	50	N-155[a]	25			Hastelloy B	50	Refractaloy 70	19	HH[a]	4.0
HH[a]	46	16-25-6	24			N-155	50	Hastelloy C[a]	18.5	Inconel 702	3.1
HT[a]	41	Inco 702[a, b]	23			S-590	50	Hastelloy B[a]	18		
HF[a]	37	A-286	22			Hastelloy C[a]	49.5	Hastelloy C	18		
HK[a]	35	Hastelloy X	22			N-155[a]	49	Hastelloy B	17		
Hastelloy X[a]	34	Hastelloy X[a]	20			Hastelloy X	44	Inconel 702	16		
		19-9DL	20			X-40[a]	44	Hastelloy X	15.5		
		HT[a]	16.5			16-25-6	44	Discaloy	15		
		HH, HK[a]	16			19-9DL	44	A-286	14		
		HF[a]	13			HH[a]	35	16-25-6	13.5		
						Hastelloy X[a]	32	19-9DL	13		
						HT[a]	32	HT[a]	12		
						Hastelloy X[a]	32	HH[a]	11.5		
						HF[a]	30	HK[a]	10.5		
						HK[a]	25	HF[a]	9		

[a] Cast. [b] Estimated. [c] Sheet. [d] Annealed or recrystallized. [e] Stress relieved.

Stress-Rupture Strength of High Temperature Alloys

1000 Hr

1200 F		1350 F		1500 F		1600 F		1700 F		1800 F	
Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi
René 41	102	Inconel 713C[a]	70	Inconel 713C[a]	41	Udimet 700	29	Inconel 713C[a]	17.5	Molybdenum[c]	44
Udimet 700	101	Udimet 500	67.5	1753	34	Inconel 713C[a]	28	X-40[a]	14.5	Columbium[c]	25
1753	98	Inconel 700	59	Udimet 500	32	1753	22	1753	12	X-40[a]	9.8
Udimet 500	94	Waspaloy	52	Inconel 700	31	Udimet 500	20.5	René 41	11	Inconel 713C[a]	9
U-212	88	W-545	50	GMR-235[a]	29	GMR-235[a]	18	HS-21[a]	10	HS-21[a]	7
Inconel 700	87	D979	47	René 41	29	X-40[a]	18	Inconel 700	8.6	S-816	6.5
Waspaloy	86	GMR-235[a]	47	Waspaloy	26.5	René 41	17	HS-25	8.4	1753	6.5
D979	79	M-252	43	X-40[a]	23.5	Waspaloy	16.5	Hastelloy C[a]	6.0	HS-25	5
M-252	79	U-212	42.5	M-252	22.5	Inconel 700	16	N-155	4.8	HT[a]	3.7
Inconel X	68	Inconel X	40	D979	22	M-252	13.5	HT[a]	4.7	Hastelloy X	3
W-545	66	S-816	40	S-816[a]	21	HS-21[a]	13.4	HH[a]	3.9	HK[a]	3
Refractaloy 26	63	X-40[a]	39	S-816	19	S-816[a]	13	HK[a]	3.8	Hastelloy X[a]	2.9
Incoloy 901	62	Refractaloy 26	38	Inconel X	18	HS-25	12	Inconel 702[b]	3.5	N-155	2.6
HS-25	54	HS-25	34	Refractaloy 26	18	Refractaloy 70	10			HH[a]	2.5
S-816	51	Incoloy 901	30	HS-25	17	S-816	10			Inconel 702[b]	2.4
X-40[a]	51	S-816[a]	29	N-155	16	Hastelloy C[a]	9.2				
N-155[a]	47	Hastelloy B[a]	25.5	S-590	16	S-590	9.0				
A-286	46	Hastelloy C[a]	25	Refractaloy 70	15	N-155	7.2				
HS-21[a]	44.2	S-590	25	Hastelloy C[a]	14.5	Hastelloy X	7				
S-816[a]	44	N-155[a]	24	HS-21[a]	14.2	Inconel X	7				
Hastelloy C	43	Refractaloy 70	24	N-155[a]	14	HT[a]	7				
N-155	43	Hastelloy C	23	Hastelloy B[a]	12.7	HU[a]	6				
Nivco	43	HS-21[a]	22	Hastelloy C	12.5	Inconel 702[b]	5.1				
Hastelloy C[a]	42.5	N-155	22	Incoloy 901	11	HK[a]	5				
Refractaloy 70	42	A-286	21	Hastelloy X	10						
Discaloy	41	16-25-6	21	V-36[e]	10						
Inconel 702[b]	41	Inconel 702[b]	20	HT[a]	9.2						
Hastelloy B[a]	40.5	19-9DL	19	Hastelloy X[a]	9.1						
S-590	38	Hastelloy X	18.5	16-25-6	9						
19-9DL	37	V-36[e]	18	19-9DL	9						
Hastelloy B	36.5	Hastelloy B	17	Inconel 702[b]	8.8						
16-25-6	34	Hastelloy X[a]	16	HH[a]	8.2						
Hastelloy X	33	HT[a]	15.2	A-286	7.7						
V-36[e]	30	HH[a]	14.9	HK[a]	7						
Hastelloy X[a]	26.5	HF[a]	12	HF[a]	6.5						
HH[a]	26.5	HK[a]	11								
HT[a]	25										

[a] Cast. [b] Estimated. [c] Sheet. [d] Annealed or recrystallized. [e] Stress relieved.

10,000 Hr

1200 F		1350 F		1500 F		1600 F	
Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi
Waspaloy	67	U-500	46	U-500	24	Waspaloy	11
M-252	64	Waspaloy	39	Waspaloy	17.5	M-252	8.2
S-816	40	M-252	33	S-816	16	S-816	7.5
N-155	35	S-816	24	M-252	14	HT	4.9
A-286	32	N-155	17	N-155	11.5	HH	3.9
19-9DL	31	19-9DL	12.5	HT	6.9	HK	3.4
HH, HT	20	HT	11.5	HH	6.0		
				19-9DL	5.6		
				HK	4.7		

Effect of Radiation on Materials

EFFECT ON TENSILE PROPERTIES OF METALS

Metal	Condition of Metal	Irradiation: Temp, F	Irradiation: Integrated Fast Neutron Flux, n/sq cm	Yield Strength: Unirrad, 1000 psi	Yield Strength: Change After Irrad, 1000 psi	Tensile Strength: Unirrad, 1000 psi	Tensile Strength: Change After Irrad, 1000 psi	Elongation: Unirrad, %	Elongation: Change After Irrad,* %
CARBON STEELS									
ASTM A212B	Normalized at 1904 F	176	10^{19}	51	14.4	75	6.8	23	−5
ASTM A212B	Same as Above	176	10^{20}	51	42	75	25	23	−18
ASTM A302B		500	3.7×10^{18}	65	7.1	91.5	3.8	26	−2
ASTM A302B		698	3.7×10^{18}	64.2	3.3	89.8	2.8	27	−1
STAINLESS STEELS									
347			2.6×10^{22}	61.6	39.2	95.8	11.4	63.2	19.2
316	Annealed	104	5×10^{20}	—	—	79	71	—	—
440 C	Hardened		5×10^{19}	185	18	205	35	—	—
301		176	4×10^{19}	38.4	48.6	98.7	14.5	56	−8
304 ELC		176	8×10^{19}	24.4	51.1	86.3	17.5	63	−5
302		176	4×10^{19}	33.9	50.1	95.5	15.8	—	—
302 B		176	4×10^{19}	33.5	48	107.8	17.2	—	—
305		176	4×10^{19}	32.1	39.3	98	5.6	—	—
347		176	4×10^{19}	37	59.5	97.6	17.2	49	−24
321		176	8×10^{19}	31.2	59.4	84.8	21	—	—
410	Annealed		10^{20}	147.7	35.1	177	24	20	−5
ALUMINUM ALLOYS									
1100			2.6×10^{22}	18.4	8.1	20.3	10.1	22.3	0.7
356			2.6×10^{22}	24.1	11.9	32.4	12.6	2.7	−1.2
1100-O		149	10^{20}	6.8	10.3	13.6	12.4	38.2	−17
1100-H14		149	10^{20}	16.6	7.4	17.3	8.7	6	−0.5
6061-O		149	10^{20}	9.5	16.1	18.1	19.2	28.8	−6.4
6061-T6		149	10^{20}	38.5	5.9	45	5.6	17.5	−1.3
NICKEL ALLOYS									
Monel	As Received	104	4×10^{19}	—	—	85	11	33	−23
K Monel	As Received	104	4×10^{19}	—	—	123	11	11	−8
Inconel	As Received	104	4×10^{19}	—	—	106	10	31	−2
Inconel X	As Received	104	4×10^{19}	—	—	126	7	37	−14
Hastelloy C	Cast		4×10^{19}	—	—	80	27	—	—
Hastelloy C	Wrought	104	4×10^{19}	—	—	138	4	20	−8
Hastelloy X	Annealed		5×10^{19}	49.4	50.8	112.5	16.8	52	−2
Inconel 702	Annealed		5×10^{19}	42.6	58.5	94.9	18.2	67	−17
Inconel X	Aged Once		2×10^{20}	120.3	50.5	184.3	−10.3	23	−10
K Monel	Annealed		5×10^{19}	132.4	35.2	163.4	5.3	22	−10
OTHER METALS									
Copper	Annealed	212	5×10^{19}	8.4	21.9	27.1	7.2	42.2	−14.7
Nickel	Annealed	212	5×10^{19}	36.2	25.3	58.6	4.3	34.4	−11
Molybdenum	Stress Relieved	212	5×10^{19}	93.7	5.7	99.8	4.5	23.6	−1.6
Tungsten	Fully Recrystallized	212	5×10^{19}	—	—	137	15	0	0
Titanium	Annealed	212	5×10^{19}	79.8	8.9	83.4	8.8	10.4	−2.1
Zirconium	Heavily Cold Worked	212	5×10^{19}	107	−1	123.5	0.8	3.5	0.7
Tungsten	As Received		5×10^{19}	—	—	153	−36	0	0
Tantalum	As Received		5×10^{19}	—	—	68	19	21	−4
Stellite 3	As Received		5×10^{19}	—	—	86	8	—	Low
Zircaloy 2	Annealed	122	10^{21}	44.1	25.9	68.4	11.6	23	−8
Zircaloy 2	50% Cold Worked	122	1×10^{21}	79.6	24.9	98.3	16.2	19.5	−10.3
QMV Beryllium			7×10^{21}	24.5	—	35.7	14.7	1.4	−1.2
Zirconium	Annealed	158	2×10^{20}	34.5	21.6	64.1	7.1	33	−11
Zirconium	50% Cold Worked	158	2×10^{20}	83.7	10.8	86.7	9	11	−4

* All changes are plus unless otherwise indicated.

EFFECT ON HARDNESS OF METALS

Metal	Condition of Metal	Irradiation: Temp, F	Irradiation: Integrated Fast Flux, n/sq cm	Brinell Hardness: Un-irrad	Brinell Hardness: Change After Irrad[a]
PLAIN CARBON STEELS					
1018	Annealed	104	10^{19}	138	23
1018	Hardened	104	10^{19}	237	6
1042	Annealed	104	10^{19}	225	−38
1042	Hardened	104	10^{19}	390	36
1045	Annealed	104	10^{20}	187	0
1095	Annealed	104	10^{19}	290	25
1095	Hardened	104	10^{19}	535	0
STAINLESS STEELS					
410	Annealed		3×10^{20}	318	10
16-1 Croloy	Annealed		8×10^{19}	159	57
347 C	Annealed	203	10^{20}	—	82
304	Surface Nitrided	104	5×10^{20}	654	156
316	Annealed	104	5×10^{20}	154	74
410	Surface Nitrided	104	5×10^{20}	656	84
440 C	Hardened	104	5×10^{20}	545	0
440 C	Hardened		4×10^{19}	461	73
USS "W"	Hardened	104	5×10^{20}	461	0
NICKEL ALLOYS					
Hastelloy C	Cast		5×10^{19}	228	132
Hastelloy C	Wrought	104	4×10^{19}	209	0
Monel	Annealed	104	4×10^{19}	150	59
K Monel	As Received	104	4×10^{19}	260	25
Inconel	As Received	104	4×10^{19}	175	65
Inconel X	Annealed	104	4×10^{19}	209	56
Hastelloy X	Annealed		5×10^{19}	172	44
Inconel 702	Annealed		5×10^{19}	156	60
Inconel X	Aged Twice		10^{19}	265	21
Inconel X	Aged Once		10^{19}	301	17
K Monel	Annealed		5×10^{19}	271	9
OTHER METALS					
Copper[b, c]		194	5×10^{20}	44	56
Nickel[b, c]		194	5×10^{20}	61	55
Titanium (75A)[c]		194	5×10^{20}	177	33
Zirconium[b, c]		194	5×10^{20}	69	21
Iron[b, c]		194	5×10^{20}	53	42
Molybdenum[c]		194	5×10^{20}	204	23
1100 Aluminum			2×10^{21}	38	34
1100 Aluminum			3×10^{22}	38	38
356 Aluminum			2×10^{21}	67	29
QMV Beryllium			2×10^{21}	127	52
Stellite 3			5×10^{19}	420	55
Tungsten			5×10^{19}	—	0
Tantung G			5×10^{19}	—	0
Tantalum			5×10^{19}	147	53

[a] All changes are plus unless otherwise indicated.
[b] High purity. [c] Annealed.

EFFECT ON IMPACT PROPERTIES OF METALS

Metal	Irradiation: Temp, F	Irradiation: Integr Fast Neutron Flux, n/sq cm	Change in Transition Temp, °F[a]
FERROUS METALS			
Iron	527	10^{20}	Increase
ASTM A302B Steel[b, e]	500	4×10^{18}	11
Same as Above	698	4×10^{18}	11
ASTM A212B Steel[d]	176	10^{19}	9
Same as Above	176	10^{20}	103
ASTM A212 Steel[f]	122	10^{20}	151
ASTM A212 Steel	428	2×10^{18}	34
ASTM A212 Steel	572	2×10^{18}	45
NONFERROUS METALS			
Tungsten[g]	212	5×10^{19}	14
Molybdenum	212	5×10^{19}	185
Zirconium	104	5×10^{19}	Small
Aluminum	527	10^{20}	Decreases
Copper	527	10^{20}	Increases
Nickel	527	10^{20}	Increases

[a] Numerical changes indicated are positive.
[b] Normalized at 1650 F. [c] Standard V-notch Charpy.
[d] Normalized at 1900 F. [e] Subsize Izod.
[f] Subsize notched cylinders. [g] Subsize tension test.

EFFECT ON DENSITY OF METALS

Material	Irradiation: Integr Fast Neutron Flux, n/sq cm[a]	Density: Unirrad, lb/cu in.	Density: Change After Irrad, %[b]
1100 Aluminum	240	0.0978	−0.004
356 Aluminum	240	0.0962	−0.02
QMV Beryllium	240	0.0665	0
347 Stainless Steel	240	0.285	−0.003
316 Stainless Steel	3.5	0.288	−0.06
347 Stainless Steel	3.5	0.286	−0.09
347+Ta Stainless Steel	3.5	0.286	−0.04
410 Stainless Steel	3.5	0.277	−0.05
"A" Nickel	3.5	0.321	−0.07
Monel	3.5	0.319	−0.05
Stellite 3	3.5	0.309	0.06
Stellite 6	3.5	0.301	0.11
ASTM A212 Steel	3.5	0.283	0
Tantalum	5	—	−0.10
Tungsten	5	—	−0.15
Tantung G	5	—	−0.20 to −0.25
WC-Co, TAC-Co	8	—	−0.3 to −0.6
TiC-Ni	8	—	−0.3 to −0.6

[a] 104 F. [b] All changes are plus unless otherwise indicated.

continued on next page

Effect of Radiation on Materials

EFFECT ON CERAMICS AND ALLIED MATERIALS

Material	Exposure	Effects
CERAMIC OXIDES		
Al_2O_3[a]	2×10^{20} n/sq cm	No chg in x-ray pattern and ther cond. Some color chg
BeO[b]	2×10^{20} n/sq cm	0.3% exp in c_o, none in a_o as det by x-ray pattern. No chg in ther cond
MgO[c]	2×10^{20} n/sq cm	No chg in basic lattice. Single crystal broken into reactive small crystals
Quartz	10^{21} n/sq cm	Decr in density to 2.25. Chg in axial ratio (c/a) from 4.1 to about 1.06. Signif energy release shown by DTA at 1110 F
SiO_2	10^{21} n/sq cm	Decr in density to about 2.25 (17.7% chg). No macroscopic defects or loss of structure. Color chg
SiO_2[d]	2×10^{20} n/sq cm	Incr in density to 2.25. Heating at red heat removes increase. Color chg to deep violet or dark brown
SiO_2[d]	2×10^{10} ergs/gm (C), electrons	Highly purified silica shows no discolor. Comm silica appears dark, mottled
TiO_2[e]	2×10^{20} n/sq cm	No chg in x-ray pattern. Slight decr in ther cond. Color chg
ZrO_2[e]	2×10^{20} n/sq cm	Rad-induced phase chg, monoclinic to cubic. No chg in cubic lattice. Slight decr in ther cond
MISCELLANEOUS CERAMICS		
Spinel, Forsterite, Porcelain, Steatite	2×10^{20} n/sq cm	No chg in crystal structure. Decr in ther cond (factor of 2). Color chg
Cordierite	2×10^{20} n/sq cm	Loss of crystallinity. Decr in ther cond (factor of 4). Color chg
Zircon	1×10^{20} n/sq cm	1.9% exp. Large loss of crystallinity
Zircon	2×10^{20} n/sq cm	Complete loss of crystallinity. Decr of ther cond (factor of 5). Color chg
$BaTiO_3$	2×10^{20} n/sq cm	2.87% exp in a_o. Marked color chg
Mica (muscovite)	10^9 ergs/gm (C), gamma	No effects noted

[a] Effects noted on both single crystals and hot pressed materials.
[b] Hot pressed. [c] Single crystal.
[d] Vitreous. [e] Polycrystalline, sintered.

EFFECT ON GLASS

Glass Type	Type of Radiation or Dosage	Property Change
PHOSPHATE GLASSES		
K-Ba-Al Phosphate	Gamma	Colors easily
Ca Metaphosphate	Gamma	Abs peak near 4700 A
Silver (activated)	Gamma	Abs near UV
Lead-Containing (60% w/o PbO)	10^{14} n/sq cm	No discolor melts
SPECIAL GLASSES		
Pure GeO_2 Glass	Gamma	Insensitive at 10^8–10^9 ergs/gm (C)
1 PbO–1.3 P_2O_5	2×10^{20} n/sq cm	Slight discolor
1 PbO–1.22 V_2O_5	2×10^{20} n/sq cm	No signif chg
1 PbO–1.5 SiO_2	2×10^{20} n/sq cm	Chg from yellowish clear to amber clear; considerable decr in hardness
0.8K_2O–0.2CaO–2.75 SiO_2	2×10^{20} n/sq cm	Chg from colorless to gray
$Li_2O \cdot 3B_2O_3$, $Na_2O \cdot 2B_2O_3$, K_2O–$2B_2O_3$, $Rb_2O \cdot 2B_2O_3$	3×10^{10} ergs/gm (C), gamma	Abs 10 times greater than for fused B_2O_3
OTHER GLASSES		
Lead Glass (window)	Gamma	May develop brown color
Soft Glass	5.8×10^{19} n/sq cm	Dark color, slight incr in ten str; decr in impact str
Optical Glass (crown and flint)	10^6–10^8 ergs/gm (C)	Develops color at 10^6 ergs/g (C) or less; useless at 10^8 ergs/gm
Optical Glass (protected: cont 1-2% CeO_2)	X-ray or gamma	No color at 10^8 ergs/g (C); usable at 5×10^{10} ergs/gm (C)
Soda-Lime-Silica Glass (cont cobalt)	Gamma	Color chg sensitive to dosage; suitable for dosimeter
Fused Silica General	All types of high-energy rad	Color centers form; abs band at 214 mμ
Pure	Fast neutrons	Density may chg from 2.2 to 2.27
	10^{11} ergs/gm (C), gamma	No chg in abs
	Reactor, gamma	Intense abs band at 218 mμ
With Al Impurity	X-ray, UV	Develops abs bands at 5500, 2950 and 2150 A
Borosilicate	10^{20} n/sq cm	Develops large cracks
Pyrex (borosilicate)	5.8×10^{19} n/sq cm	Color darkens; slight incr in ten and impact str

EFFECT ON PLASTICS LAMINATES

Material	Irradiation			Tensile Strength, psi		Flexural Modulus, 10^6 psi	
	Exposure, ergs/gm (C)	Temp, F	Exp Time, hr	Unirrad, 1000 psi	Chg After Irrad, 1000 psi	Unirrad	Chg After Irrad
Silicone (flexure test)	8.5×10^9	Room	200	31.7	−0.3	3.06	−0.12
	2×10^9	500	50	12.4	+1.2	1.9	+0.10
	4×10^9	500	100	13.4	−1.7	2.0	0
	8.5×10^9	500	200	14.1	−4.2	2.0	−0.1
Heat Resistant Epoxy (compression test)	8.5×10^9	Room	200	46.7	0	—	—
	2×10^9	500	50	3.7	+0.1	—	—
	4×10^9	500	100	4.1	+1.3	—	—
	8.5×10^9	500	200	4.7	+1.6	—	—
Phenolic (flexure test)	8.5×10^9	Room	200	84.5	−0.5	4.2	+0.1
	2×10^9	500	50	27.3	+27.7	3.1	+0.3
	4×10^9	500	100	17.7	+24.3	2.6	+1.0
	8.5×10^9	500	200	12.3	+3.3	2.1	+0.3

EFFECT ON PLASTICS AND RUBBER MATERIALS[a]

Material ↓	Beginning of Moderate Damage, ergs/gm (C)[b]	Beginning of Sericus Damage, ergs/gm (C)
PLASTICS MATERIALS		
Phenolic Laminates	$>10^{12}$	$>10^{12}$
Polystyrene	7.5×10^{10}	6.5×10^{11}
Polyester Laminates	7.5×10^{10}	5.5×10^{11}
Phenolics, Mineral-Filled	5×10^{10}	5×10^{11}
Silicones, Glass-Reinforced	5×10^{10}	5×10^{11}
Epoxy Resins	10^{10}	9×10^{10}
Phenolics, Unfilled	4.5×10^9	3×10^{10}
Polyvinyl Chloride	4.5×10^9	5×10^{10}
Amino Resins	2×10^9	9×10^9
Polyethylene	10^9	9×10^9
Cellulosics	8×10^8	5×10^9
Silicones	10^8	4.5×10^9
Polyamides	10^8	10^9
Polyesters, Unfilled	10^8	2.5×10^8
TFE Fluorocarbon	5×10^6	2.5×10^7
RUBBER MATERIALS		
Urethane	7.5×10^9	4.5×10^{10}
Natural	6×10^9	3×10^{10}
SBR	3.5×10^9	3×10^{10}
Nitrile	2×10^9	9.5×10^9
Neoprene	2×10^9	9.5×10^9
Acrylic	0.5×10^9	10^{10}
Silicone	8×10^8	6×10^9
Fluoroelastomers	8×10^8	4×10^9
Polysulfide	1.5×10^8	4.5×10^8
Butyl	0.5×10^8	4×10^8

[a] Estimated from graph.
[b] Incipient to mild damage at about $10^5 - 10^7$ ergs/gm (C).

Machinability of Metals

Material	Machinability Index*	Material	Machinability Index*
Magnesium Alloys	500–2000	Ingot Iron	50
Aluminum Alloy (218-T), Cast	240	Stainless Steels (201, 202, 304, 309, 310, 316)	50
Free-Cutting Brass	200	Tool Steels (A)	50
Aluminum Alloy (2011)	200	Wrought Iron	50
Zinc	200	Low Alloy Steels, Cast	30–70
Aluminum Alloys (5052, 5056, 6061, 6063)	190	High Carbon Steels, Ann.	43–53
Aluminum Alloys (3003, 3004)	180	Low Alloy Steels (23XX)	40–55
Aluminum Alloys (112, B-113, 750-T), Cast	180	Low Carbon Steels, HR	40–50
Sulfur Copper	180	Stainless Steels (420, 431)	45
Architectural Bronze	180	Low Alloy Steels (48XX)	45
High-Leaded Brass	180	Tool Steels (D)	45
Leaded Commercial Bronze	180	Copper, Electrolytic Tough Pitch	40–50
Leaded Copper	160	Tool Steels (M)	40
Forging Brass	160	Stainless Steels (440A, B, C)	40
Leaded Nickel Silver	160	19–9DL	40
Aluminum Alloy (2024)	150	Copper, 99.5%	40
Leaded Phosphor Bronze	100–200	Nickel Silvers	40
Aluminum Alloys (108, 122, A-356), Cast	140	Zirconium Copper	40
Aluminum Alloys (2014, 2017, 6051)	140	Chromium Copper	40
Low-Leaded Brass	140	Phosphor Bronzes (A, C, D, E)	40
Leaded Naval Brass	140	Cupro-Nickels	40
Leaded Muntz Metal	120	Gilding, 95%	40
Aluminum Alloy (7075)	120	Commercial Bronze, 90%	40
Leaded Silicon Bronze	120	Beryllium Copper	40
Leaded Naval Brass	120	Phosphorized Copper	40
Malleable Iron (standard)	120	Oxygen-Free Copper	40
Gray Iron (ferritic)	110	Titanium Alloys (A-55, A-70)	38
Nodular Iron	90–110	Low Alloy Steels (92XX)	36–38
Malleable Iron (pearlitic)	80–90	Tool Steels (H)	37
Aluminum Bronzes, Cast	60–100	Low Alloy Steels (61XX)	26–46
Stainless Steel (416)	80	Tool Steels (T)	34
Muntz Metal	80	16–25–6	31
Stainless Steel (303)	65	Titanium Alloy (A-110)	29
Medium Carbon Steels, Ann.	65	A-286	27
Medium Carbon Steels, CW	60–67	Titanium Alloy (C-120)	26
Carbon Steels, Cast	55–70	Discaloy	25
Low Alloy Steels (40XX)	52–73	V-57	25
Low Alloy Steels (13XX)	59–62	Titanium Alloy (C-130)	24
Low Alloy Steels (51XX)	55–67	Incoloy 901	20
Stainless Steel (405)	60	Titanium Alloy (C-140)	20
Yellow Brass	60	Refractaloy 26	20
Red Brass, 85%	60	S-590	15–20
Silicon Bronzes (A, B)	60	Multimet, N-155	15
Tool Steels (W)	60	Inconel X	15
Naval Brass	60	Titanium Alloy (MST)	13
Cartridge Brass, 70%	60	Hastelloy B	12
Low Brass, 80%	60	HS 25, L-605	12
Tool Steels (L)	56	Hastelloy C	10
Low Alloy Steels (41, 43XX)	51–62	S-816	9
Stainless Steels (305, 347, 348, 302,		Udimet 500	9
321, 403, 410)	55	Inconel 700	8
Tool Steels (S, O)	54	Inconel 713 C	6
Low Alloy Steels (86, 87XX)	45–61	HS 21	6
Low Carbon Steels, CW	45–60	HS 31, X-40	6

* Based on AISI B1112 = 100

Prices of Materials[a]

$/lb

Material	Cost per lb	Cost per cu in.	Material	Cost per lb	Cost per cu in.
Rhodium	2012	899	Polysulfide Rubber[d]	.50–1.25	.02–.06
Platinum	1240	961	Diallyl Phthalate[m]	.85	—
Osmium	1167	957	Nickel[e]	.81	.24
Gold	510	356	1415 NW (Greek Ascoloy)[l]	.78	.22
Palladium	365	158	Phosphor Bronze (A), 5%[i]	.75	.24
Beryllium	70	4.69	17-7 PH[f]	.69	.19
Columbium[b]	36–55	11–17	Ethyl Cellulose[m]	.67	.026
Beryllium Copper	43	12.77	1430 MV (Lapelloy)[l]	.65	.18
Tantalum[c]	35	21	1420 WM (422)[l]	.65	.18
Indium	32.80	—	Acetal[m]	.65	.033
Kel-F Rubber[d]	16	—	Nickel Silver, 10%[i]	.64	.20
Silver	13.25	5.02	Cellulose Propionate[m]	.62	.027
Viton Rubber[d]	10–13	—	Epoxy[m]	.62	.04
Lithium[e]	9	—	Silicon Bronze[i]	.60	.18
Molybdenum[f]	8	2.90	Butadiene-Acrylonitrile Rubber[d]	.46–.68	.017–.023
CFE-Fluorocarbon	7.00–8.50	.53–.61	Neoprene Rubber[d]	.39–.75	.017–.033
Unitemp 1753[g]	7.50	2.29	Manganese Bronze[i]	.57	.17
M-252[g]	6.98	2.08	Naval Brass[i]	.53	.16
Zirconium[h]	6.50	1.56	Commercial Bronze, 90%[i]	.53	.16
Glass-Silicone Laminate[i]	5.90–6.50	.34–.38	Red Brass, 85%[i]	.52	.16
Waspaloy, M-252[j]	6.20	1.79–1.80	Alkyd[m]	.43–.60	.03–.04
Haynes Alloy 25, L-605[l]	5.78	1.90	Cellulose Acetate Butyrate[m]	.40–.62	.02–.03
S-816[l]	5.46	1.69	Muntz Metal, Low Brass, 80%[i]	.51	.15
Tellurium	3.50–5.00	—	Acrylic[m]	.46–.55	.018–.023
UT-212[g]	4.25	1.21	Polypropylene[m]	.42–.58	.013–.019
TFE-Fluorocarbon[m]	3.25–5.00	.25–.385	Unimach I, UCX2[l]	.50	.13–.14
Hastelloy Alloy B[k]	3.77	1.24	Austenitic Stainless Steels[f]	.39–.58	.11–.16
Hastelloy Alloy C[k]	3.72	1.20	ABS Resins[m]	.47–.49	.017–.018
Nylon-Phenolic Laminate[i]	3.50–3.90	.14–.15	Yellow Brass[i]	.48	.14
Multimet Alloy, N-155[k]	3.65	1.08	Cellulose Acetate[m]	.35–.58	.021–.028
UT 901[j]	3.58	1.00	Melamine[m]	.42–.45	.022–.023
Vanadium	3.45	.79	Copper Anodes	.38–.46	—
Tungsten[b]	2.75–4.00	1.65–2.40	Magnesium (casting alloys)	.41	.026
Hastelloy Alloy F[k]	3.31	—	Styrene-Acrylonitrile[m]	.40–.41	—
S-590[l]	3.31	.99	Ferritic Stainless Steels[f]	.31–.41	.08–.11
Hastelloy Alloy X[k]	3.12	.90	Magnesium[n]	.36	.02
Silicone Rubber[d]	2.50–4.00	.08–.11	Manganese	.34–.36	—
Silicone Plastic[m]	2.40–3.55	.16–.24	Vinyls[m]	.24–.43	.01–.02
Glass-Phenolic Laminate[i]	2.60–3.25	.14–.19	14 CMV (Chromalloy)[l]	.33	.09
Chlorinated Polyether[m]	2.50	.126	Polyester[m]	.26–.39	.012–.018
Glass-Melamine Laminate[i]	2.30–2.50	.15–.17	Martensitic Stainless Steels[f]	.29–.36	.08–.09
Bismuth	2.25	—	17-22-AS[l]	.32	.09
Discaloy[j]	2.00	.57	Copper[e]	.31	.10
Asbestos-Phenolic Laminate[i]	.96–2.70	.05–.16	Graphite (electrodes, 8–10 x 60 in.)	.30	—
A-286[j]	1.72	.49	Natural Rubber[d]	.30	.01
Cadmium	1.60	—	Antimony	.29	—
Nylon[m]	.98–2.18	.04–.09	Polystyrene (impact)[m]	.28–.29	.01
Titanium[h]	1.50–1.60	.24–.26	High Density Polyethylene[m]	.28	.01
Cotton-Phenolic Laminate[i]	1.20–1.90	.06–.09	Aluminum (alloys)[e]	.26–.29	.02–.03
Polycarbonate[m]	1.30–1.75	.056–.075	Phenolic[m]	.20–.35	.01–.02
Cobalt	1.50	.48	Urea[m]	.19–.34	.01–.018
AM 350, AM 355[j]	1.43	.40	Butyl Rubber[d]	.23–.30	.007–.009
Urethane Rubber[d]	1.15–1.65	.05–.07	Aluminum (primary)[e]	.26	.025
Chromium	1.31	—	Butadiene-Styrene Rubber[d]	.14–.35	.004–.01
Unimach I[j]	1.30	.36	Low Density Polyethylene[m]	.23–.24	.008
Tin Anodes	1.20	—	Zinc Anodes	.19–.22	—
Tin	1.16	.31	Polystyrene (GP)[m]	.17–.18	.006–.007
Nickel Anodes	1.05	—	Zinc (casting alloys)	.14–.15	.03–.04
Paper-Phenolic Laminate[i]	.82–1.22	.04–.06	Carbon Electrodes (20 x 90 in.)	.12	—
300M[j]	.99	—	Zinc	.11–.12	.028–.03
UCX2 (MX2)[j]	.98	.27	Lead	.11	.045
19-9DL[l]	.98	.28	Alloy Steel	.04	—
AM 350, AM 355[l]	.90	.25	Carbon Steel	.038	.01
PH 15-7 Mo[f]	.89	.24	Iron[n]	.025–.03	—

[a] All prices are approximate (based on latest information as of July 25, 1961) and are published for general guidance and comparison only. Prices are for large quantities for range of grades, sizes, colors, etc.; various extras, discounts, etc. are not included. Cost per cubic inch was derived by multiplying dollars per lb by density (lb per cu in.).
[b] Powder. [c] Melting stock. [d] Dry. [e] Ingot. [f] Billet. [g] Induction vacuum melted bar.
[h] Sponge. [i] Sheet. [j] Consumable electrode vacuum melted bar. [k] 2-in. bar.
[l] Electric arc furnace melted bar (2-in.). [m] Molding compound or resin. [n] Pig.

SUPPLIERS' LITERATURE

IRONS AND STEELS

Iron Powders. Alan Wood Steel Co., 4 pp, illus., No. 962. Information on services and facilities available for the production of iron powders. **1**

High Strength Steel. Allegheny Ludlum Steel Corp., 24 pp, illus., No. TS-38. Composition, heat treatment, fabrication data, room and elevated temperature properties, typical applications and other information on structural uses of a high strength steel. **2**

Iron Powders. American Metal Climax Inc., Pyron Co., Amco Div., 8 pp, illus. Chemical and physical properties, and composition of hydrogen-reduced iron powders. **3**

Stainless Steels. Armco Steel Corp., Armco Div., 6 pp, illus. Information on stainless steels and facilities for producing stainless steel shapes. Also covers surface finishes for stainless steel. **4**

Alloy Steels. Bethlehem Steel Co., 44 pp, illus., No. 415C. Effects of alloying elements, grain size, heat treatment, quenching media, hardenability, carburizing, flame hardening, normalizing, annealing, cold finishing, and other basic information on alloy steels. **5**

Stainless Steel Services. G. O. Carlson, Inc., 12 pp, illus. Information on stainless steel plates, heads, forgings, rings, circles, flanges, bars, and sheets used in the metalworking, chemical process, nuclear, and aircraft and missile industries. **6**

PH Stainless Steel Alloys. Cooper Alloy Corp., 12 pp, illus. Composition ranges, mechanical properties, advantages, characteristics, corrosion rates, typical uses, and other data on four relatively new precipitation hardenable stainless steel alloys. **7**

Electric Furnace Steels. Copperweld Steel Co., Aristoloy Steel Div., 48 pp, illus. Facilities of company for melting, rolling, finishing, heat treating and conditioning electric furnace steels. Rolling limits and chemical analysis are also given. **8**

Data on Steel. Crucible Steel Co. of America, 73 pp, illus. Composition, heat treatment, and weight and conversion tables for tool, stainless, heat resisting, carbon, alloy, and special purpose steels. **9**

Stainless Steel Plate. Eastern Stainless Steel Corp., 16 pp, illus., Nos. 152, 153. Advantages, typical applications, specifications, and other information on stainless steel floor plate. **10**

Stainless Corrosion Data. Peter A. Frasse & Co., Inc., 2 pp. Chart gives relative corrosion resistance of 34 standard grades of stainless steel. Includes discussions of the four basic groups of stainless steels and describes methods of selecting the most suitable grade for a particular application. **11**

Nickel Alloy Steels. International Nickel Co., Inc., 27 pp. Buyers' Guide lists available grades and companies supplying nickel alloy steels. **12**

Steel Analyses. Jones & Laughlin Steel Corp., Stainless & Strip Div., 20 pp. Compositions and SAE, AISI and AMS numbers for 40 stainless steels, 184 alloy steels and 105 carbon steels. **13**

High Strength Steel Bar. La Salle Steel Co., 4 pp, illus. Information on how a high strength, easy to machine steel bar can be used to make a variety of parts such as shafts, pins, gears, pinions, etc. The high strength bar needs no heat treating. **14**

Vacuum Melted Steels, Alloys. Latrobe Steel Co., 8 pp, illus. Compositions, characteristics, applications, heat treatments, mechanical and physical properties, and workability of vacuum melted structural steels designed for high strength, high temperature applications; bearings, and gears. **15**

High Strength Steels. National Steel Corp., Great Lakes Steel Div., 12 pp, illus. Chemical compositions, mechanical properties, impact strengths, heat treatments, fabrication data, welding information, and other data on special high strength steels. **16**

Stainless Steel. Republic Steel Corp., 40 pp, illus., No. ADV-1124. General information, chemical analyses, typical mechanical properties, and applications of 300 series stainless steels. Also included is information on corrosion resistance, high and low temperature properties, fabrication, joining methods and available forms and finishes. **17**

Stainless Spring Steel. Sandvik Steel, Inc., 34 pp, illus., No. E-110. Characteristics, advantages, properties, sizes and tolerances, fabrication data, and other information on stainless spring steels. **18**

Stainless Steels. Sharon Steel Corp., 32 pp, illus. Compositions; physical and mechanical properties; heat treatments; and typical applications of several stainless steels. **19**

Air Hardening Tool Steel. Timkin Roller Bearing Co., Steel & Tube Div., 4 pp, illus. Composition, advantages, characteristics, properties, heat treatment, grinding practice, typical applications, and other information on an air hardening graphitic tool steel. **20**

High Temperature Steels. U. S. Steel Corp., 88 pp, illus. Discusses the nature of creep, measurement of flow under stress at elevated temperature, factors affecting high temperature properties, and behavior of steels at elevated temperatures. Includes specifications, heat treatment, composition, tensile properties, creep and rupture properties, and effect of time and temperature on impact strength and hardness of 21 different high temperature steels. **22**

Steel Strip. U.S. Steel Corp., American Steel & Wire Div., 48 pp, illus. Physical properties, dimensions, tempers and finishes of cold rolled stainless and carbon steel strip. **23**

Tool Steel Guide. Universal-Cyclops Steel Corp., Refractomet Div. Compact slide rule-type calculator identifies brand name, producer, and AISI number of over 600 tool steels. Included is a composition chart covering all AISI tool steels. **24**

Tool Steels. Vanadium-Alloys Steel Co., 9 pp, illus., No. CS. Composition, annealing, hardening, tempering, and typical uses of five tool steels. **25**

Stainless Steel. Washington Steel Corp., 32 pp, illus. Physical properties, composition, fabrication, corrosion and heat resistance, and cleanability of special purpose stainless steel sheet and strip. **26**

Iron-Base Superalloys. Westinghouse Electric Corp., Materials Mfg. Dept., 12 pp, illus., No. 52-263. General information, oxidation and corrosion resistance, metallurgical characteristics, physical properties, mechanical properties, creep-rupture properties, availability, typical applications, processing information, and other data on an iron-base superalloy. **27**

Expanded Metals. Wheeling Corrugating Co., 8 pp, illus., No. WC-227. Advantages, characteristics and available types of regular and flattened expanded metals. **28**

Corrosion Resistant Steel. Youngstown Sheet & Tube Co., 4 pp, illus. Chemical analysis, physical properties and corrosion resistance of a low alloy steel containing copper and chromium. **29**

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IRONS AND STEELS

IRONS AND STEELS

Gray Irons—Cast

Class[a] →	20	25	30
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.26	0.26	0.26
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	24-34	24-34	24-34
Coef of Ther Exp (32-212 F), per °F	6×10^{-6}	6×10^{-6}	6×10^{-6}
Magnetic?	Yes	Yes	Yes
Electrical Resistivity (68 F), microhm-cm	Varies from 50 to 200 depending on composition		
MECHANICAL PROPERTIES[b]			
Mod of Elast in Tension, psi[c]	13, 12, 9×10^6	14, 13, 11.5×10^6	16, 15, 13.5×10^6
Tensile Strength (as cast), 1000 psi	24-29, 20-24, 15-19	27-33, 25-30, 20-24	35-40, 30-34, 20-24
Transverse Strength (as cast), 1000 lb[d]	1, 2, 5.2	1.25, 2.1, 5.5	1.4, 2.2, 7.3
Deflection (as cast), in.[d]	0.14, 0.25, 0.25	0.17, 0.27, 0.30	0.16, 0.28, 0.31
Modulus of Rupture (as cast), 1000 psi	50, 53, 40	57, 56, 42	63, 58, 56
Hardness (Brinell, as cast)[e]	200, 180, 170	205, 190, 175	210, 200, 180
Fatigue Strength (endurance limit, as cast), 1000 psi[f]	—, 10, —	—, 12.5, —	—, 14.5, —
Compressive Strength (as cast), 1000 psi[g]	100, 95, 90	—, 100, —	—, 115, —
Shear Strength (as cast), 1000 psi	—, 32, —	—, 37, —	—, 44, —
FABRICATING PROPERTIES	Gray cast iron, having a ferrite matrix in which graphite flakes are dispersed, has a machinability rating of 110. When a cast iron microstructure shows alloy segregation, free carbides, steadite and free pearlite, machinability is reduced and may be as low as 40. Some castings show several structures due to cooling rate and section size		
JOINING	Can be joined by gas welding; shielded metal-arc welding using special electrodes; carbon arc welding. Preheating necessary. Can be brazed with nonferrous filler metal		
CORROSION RESISTANCE	More resistant to some types of corrosion than carbon and low alloy steels, possibly because of graphite; cast iron soil pipe usually lasts longer than steel pipe, for example. Gray irons are resistant to strong sulfuric acid, cold concentrated phosphoric and nitric acids; attacked by dilute sulfuric, phosphoric and nitric acids. Resistant to many alkalis, including sodium hydroxide, soda ash and ammonia		
USES	Machine bases, grates, housings, ornamental castings, sanitary wear, piston rings, pipe and fittings	Similar to class 20 where higher strength is required	Light brake drums, clutch plates, cylinder blocks, liners, impellers, pipe and fittings, grate bars, machine parts

[a] Specified min tensile strength, 1000 psi, ASTM A48-48.
[b] Three values are given for light, medium and heavy sections, respectively.
[c] At ¼ max transverse load.
[d] Bar diameters 0.875, 1.2 and 2.0 in., respectively. Distance between supports 12, 18 and 24 in., respectively.
[e] Considerably wider range obtainable by heat treatment.
[f] About 40% of tensile strength appears to be safe level for endurance limit.
[g] In general, compressive strength is three to five times tensile strength.

Gray Irons—Cast

Class[a] →	35	40	50	60
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.26	0.26	0.26	0.26
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	24-34	24-34	24-34	24-34
Coef of Ther Exp (32-212 F), per °F	6×10^{-6}	6×10^{-6}	6×10^{-6}	6×10^{-6}
Magnetic?	Yes	Yes	Yes	Yes
Elec Res (68 F), microhm-cm	Varies from 50 to 200 depending on composition			
MECHANICAL PROPERTIES[b]				
Mod of Elast in Tension, psi[c]	17, 16, 14.5×10^6	18, 17, 15.5×10^6	19, 19, 18×10^6	20, 19.5, 19×10^6
Ten Str (as cast), 1000 psi	38-42, 35-40, 25-33	50, 40-48, 33-45	60, 50-57, 52	70, 60-66, 50-75
Transverse Str (as cast), 1000 lb[d]	1.5, 2.6, 8	1.75, 2.9, 10	2, 3.3, 10.7	2.5, 3.7, 15
Deflection (as cast), in.[d]	0.17, 0.28 –	0.16, 0.28, 0.30	0.18, 0.28, 0.30	0.13, 0.34, 0.40
Mod of Rupture (as cast), 1000 psi	70, 69, 63	80, 78, 76	91, 88, 82	114, 98, 115
Hardness (Brinell, as cast)[e]	220, 210, 190	230, 220, 210	260, 240, 230	300, 290, 275
Fatigue Str (endur limit, as cast), 1000 psi[f]	–, 17.5, –	–, 21, –	–, 25, –	–, –, –
Compr Str (as cast), 1000 psi[g]	150, 125, –	–, 143, –	–, 150, –	–, 170, –
Shear Str (as cast), 1000 psi	–, 43, –	–, 57, –	–, –, –	–, –, –
FABRICATING PROPERTIES	Gray cast iron, having a ferrite matrix in which graphite flakes are dispersed, has a machinability rating of 110. When a cast iron microstructure shows alloy segregation, free carbides, steadite and free pearlite, machinability is reduced and may be as low as 40. Some castings show several structures due to cooling rate and section size			
JOINING	Can be joined by gas welding, shielded metal-arc welding using special electrodes, carbon arc welding. Preheating necessary. Can be brazed with nonferrous filler metal			
CORROSION RESISTANCE	More resistant to some types of corrosion than carbon and low alloy steels, possibly because of graphite; cast iron soil pipe usually lasts longer than steel pipe, for example. Gray irons are resistant to strong sulfuric acid, cold concentrated phosphoric and nitric acids; attacked by dilute sulfuric, phosphoric and nitric acids. Resistant to many alkalis, including sodium hydroxide, soda ash and ammonia			
USES	Clutch plates, crankcases, light brake-drums, liners, sleeves, cylinder blocks, impellers, machine components	Gears, camshafts, heads, liners, valves, pumps, tube supports, dies, wheels	Gears, valves, heads, blocks, steam pressure castings, dies, compressors, pumps, rams	Special brake drums, pressure castings, crusher frames, hot forming dies, heavy duty gears, hydraulic cylinders

[a] Specified min tensile strength, 1000 psi, ASTM A48-48.
[b] Three values are given for light, medium and heavy sections, respectively.
[c] At ¼ max transverse load.
[d] Bar diameters 0.875, 1.2 and 2.0 in., respectively. Distance between supports 12, 18 and 24 in., respectively.
[e] Considerably wider range obtainable by heat treatment.
[f] About 40% of tensile strength appears to be safe level for endurance limit.
[g] In general, compressive strength is three to five times tensile strength.

Nodular or Ductile Irons—Cast

Type ➜	80-60-3	60-45-10	100-75-04[a]
COMPOSITION, %	T.C. 3.3–3.8, Si 2.0–3.0, Mn 0.2–0.5, P 0.06–0.08, Ni 0–1.0, Mg 0.02–0.07	T.C. 3.4–4.0, Si 2.0–2.75, Mn 0.2–0.6, P 0.06–0.08, Ni 0–1.0, Mg 0.02–0.07	T.C. 3.4–3.8, Si 2.0–2.75, Mn 0.3–0.6, P 0.08 max, Ni 0–2.5, Mo 0-1.0, Mg 0.02-0.07
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.257	0.257	0.257
Melting Temp Range, F	2050–2150	2050–2150	2050–2150
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	18	20	—
Coef of Ther Exp (70–400 F), per °F	6.6×10^{-6}	6.6×10^{-6}	6.6×10^{-6}
Electrical Resistivity (75 F), microhm-cm	68[b]	66[b]	—
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	$22\text{–}25 \times 10^{6}$	$22\text{–}25 \times 10^{6}$	$22\text{–}25 \times 10^{6}$
Tensile Strength, 1000 psi	90–110	60–80	100–120
Yield Strength, 1000 psi	60–75	45–60	75–90
Elongation (in 2 in.), %	3–10	10–25	6–10
Hardness (Brinell)	200–270	140–190	200–240
Impact Strength (Charpy), ft-lb			
Unnotched	15–65	60–115	35–50
Notched	2–5	10–15	—
Fatigue Strength	Endurance ratio follows pattern of other ferrous materials. For soft ferritic materials, notched endurance ratio is about 50-55%; with stronger irons, the ratio drops to 30-40% or lower		
Compressive Strength	Ratio of compressive strength to tensile strength is about 2 to 1		
Creep Strength (0.0001%/hr), psi			
800 F	19,000	14,000	—
1000 F	1,750	4,000	—
1200 F	480	550	—
1400 F	—	—	—
THERMAL TREATMENT			
Ferritic Structure (ferritizing anneal)	Heat in 1600–1650 F range, cool to 1300 F, hold 1-3 hr, furnace cool to 1100 F, air cool		
Pearlitic-Ferritic Structures	Heat to 1600–1650 F, cool rapidly, reheat at 1100–1300 F		
Pearlitic Structures	Normalize by air cooling from 1600–1650 F		
Tempered Structures	Quench from 1400–1650 F (depending on composition), temper at 800–1300 F		
FABRICATING PROPERTIES			
Machinability	Depends on structure but has excellent machinability in both as-cast and annealed conditions		
Weldability	Can be welded by most fusion welding processes. For maximum ductility, welding should be done on fully annealed material. Composition affects weld quality. A 60 Ni-40% Fe filler wire is best for metal arc welding. Can be brazed with the lower melting BAg filler metals		
CORROSION RESISTANCE	Approx same corrosion resistance as gray irons of similar composition		
USES	Anvils for forging hammers; impellers, levers, cams, crankshafts, dies, jet engine burner support rings	Valve and pump bodies, pipe fittings, clamps, gear housings; tractor and farm machine parts	Track shoes, brake drums, gears, camshafts, pistons

[a]Obtained by heat treatment involving normalizing or quenching and tempering.
[b]Iron containing 1% silicon.

Nodular or Ductile Irons—Cast

Type →	120-90-02[a]	Heat Resistant	Austenitic
COMPOSITION, %	T.C. 3.4–3.8, Si 2.0–2.75, Mn 0.3–0.6, P 0.08 max, Ni 0–2.5, Mo 0–1.0, Mg 0.02–0.07	T.C. 2.8–3.8, Si 2.5–6.0, Mn 0.2–0.6, P 0.08 max, Ni 0–1.5, Mg 0.02–0.07	T.C. 3.0, Si 2.0–3.2, Mn 0.8–1.5, P 0.02 max, Ni 18–22, Cr 0–2.5
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.257	0.25	0.268
Melting Temp Range, F	2050–2150	2050–2150	2250
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	—	—	—
Coef of Ther Exp (70–400 F), per °F	6.6×10^{-6}	—	10.4×10^{-6}
Electrical Resistivity (75 F), microhm-cm	—	—	102
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	$22\text{–}25 \times 10^{6}$	$22\text{–}25 \times 10^{6}$	18.5×10^{6}
Tensile Strength, 1000 psi	120–150	60–100	58–68
Yield Strength, 1000 psi	90–125	45–75	32–38
Elongation (in 2 in.), %	2–7	0–20	7–40[c]
Hardness (Brinell)	240–325	140–300	140–200
Impact Strength (Charpy), ft-lb			
Unnotched	25–40	5–115	—
Notched	—	—	10–28
Fatigue Strength	Endurance ratio follows pattern set with other ferrous materials. For soft ferritic materials, notched endurance ratio is 50–55%; with the stronger irons, ratio drops to 30–40% or lower		
Compressive Strength	Ratio of compressive strength to tensile strength is about 2 to 1		
Creep Strength (0.0001%/hr), psi[d]			
800 F	—	—	18,500
1000 F	—	—	13,000
1200 F	—	—	5,700
1400 F	—	—	2,000
THERMAL TREATMENT			
Ferritic Structure (ferritizing anneal)	Heat in 1600–1650 F range, cool to 1300 F, hold 1–3 hr, furnace cool to 1100 F, air cool		—
Pearlitic-Ferritic Structures	Heat to 1600–1650 F, cool rapidly, reheat at 1100–1300 F		—
Pearlitic Structures	Normalize by air cooling from 1600–1650 F		—
Tempered Structures	Quench from 1400–1650 F (depending on composition), temper at 800–1300 F		—
FABRICATING PROPERTIES			
Machinability	Depends on structure but is excellent in both as-cast and annealed conditions		
Weldability	Can be welded by most fusion welding processes. For maximum ductility, welding should be done on fully annealed material. Composition affects weld quality. A 60 Ni-40% Fe filler wire is best for metal arc welding. Can be brazed with the lower melting BAg filler metals		
CORROSION RESISTANCE	Approx same corrosion resistance as gray irons of similar composition; superior to ordinary gray irons		
USES	Machine guides, pinions, gears, cams, dies, track rollers	Grate boxes, sinter pots, lead pots, glass molds, furnace doors	Impellers, grids, paper mill machine parts, pumps, valves

[a]Obtained by heat treatment involving normalizing or quenching and tempering.
[c]25–40% with 0% chromium.
[d]For 0% chromium.

Malleable Irons—Cast

Type and Grade ➔	Standard		Pearlitic
	32510	35018	
COMPOSITION, %	C 2.3–2.7, Si 1.5–0.8, Mn 0.55 max, P 0.18 max, S 0.20 max	C 2.0–2.45, Si 1.4–0.85, Mn 0.55 max, P 0.18 max, S 0.20 max	Same as standard grades except that Mn can be higher
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.259–0.263	0.259–0.263	0.260–0.268
Thermal Conductivity, Btu/hr/sq ft/°F/ft			
80 F	29.5	29.5	[b]
700 F	23.0	23.0	[b]
Coef of Ther Exp (68–212 F), per °F	5.9×10^{-6}	5.9×10^{-6}	7.5×10^{-6}
Specific Heat (70–750 F), Btu/lb/°F	0.133	0.133	—
Electrical Resistivity (68 F), microhm-cm	27–34	27–34	38.19–41.17
Magnetic?	Yes	Yes	Yes
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	25×10^{6}	25×10^{6}	28×10^{6}
Tensile Strength, 1000 psi	50–52	53–60	65–120
Yield Strength, 1000 psi	32–35	35–40	45–100
Elongation (in 2 in.), %	10–18	18–25	2–16
Reduction of Area, %	18–23	18–23	—
Hardness (Brinell)	110–156	110–156	160–285
Impact Strength (Charpy), ft-lb[a]	16.5	16.5	12
Fatigue Strength			
Endurance Limit, 1000 psi	25	31	30–32
Endurance Ratio	0.50	0.57	0.40
Mod of Elast in Compression, psi	25×10^{6}	25×10^{6}	23×10^{6}
Compressive Yield Strength, 1000 psi			
1% Permanent Set	28	28	43
At Failure	90+	90+	197–290
Ultimate Shear Strength, 1000 psi	45–48	48–54	65–100
Yield Strength in Shear, 1000 psi	29–32	32–36	—
Mod of Rupture in Torsion, psi	58,000	58,000	—
Poisson's Ratio	0.17	0.17	—
Allowable Working Stress (775 F), psi	5600	5600	—
THERMAL TREATMENT			
Hardening Temp, F	1500[c]	1500[c]	1500
Tempering Temp, F	—	—	About 600
FABRICATING PROPERTIES			
Casting Temperature Range, F	2600–2800	2600–2850	2600–2850
Shrinkage Allowance (contraction minus expansion during anneal), in.	11/64–1/32	11/64–1/32	11/64–1/32
Machinability Index (AISI B1112 steel = 100)	120	120	80–90
Weldability	Not fusion welded. Can be soldered and brazed		
CORROSION RESISTANCE	Resistant to atmospheric corrosion in rural, industrial and marine atmospheres; fresh and salt waters		
USES	Gear cases, brake supports, journal boxes, pipe fittings, pole line hardware, ordnance parts, marine deck fittings, anchors, parts for domestic appliances and business machines		Rocker arms, camshafts, gears, sprockets, tractor parts, agricultural machinery parts

[a] V-notch 0.079 in. deep, 0.394-in. sq bar.
[b] Estimated to be somewhat higher than for standard grades.
[c] Must first be heated to 1700 F to dissolve massive carbides.

Ingot and Wrought Irons

Type →	Ingot Iron	Wrought Iron	
COMPOSITION, %	C<0.02, Mn<0.02, Si trace, P 0.005, S 0.02	C 0.02, Mn 0.06, Si 0.13, P 0.13, S 0.01, slag 2.5	
PHYSICAL PROPERTIES			
Density, lb/cu in	0.28	0.278	
Melting Point, F	2794	2750	
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	38	34.5	
Coef of Ther Exp (68–212 F), per °F	6.8×10^{-6}	7.4×10^{-6}	
Specific Heat, Btu/lb/°F	0.11	0.11	
Electrical Resistivity (68 F), microhm-cm	9.7	11.97	
Magnetic?	Yes	Yes	
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	29.8×10^6	29.5×10^6	
		Longitudinal[a]	Transverse[a]
Tensile Strength, 1000 psi			
Annealed	42	—	—
Hot Rolled	44	48 (min)	39
Cold Drawn	73	—	—
Yield Point, 1000 psi			
Annealed	19	—	—
Hot Rolled	23	27 (min)	27
Cold Drawn	69	—	—
Elongation (in 2 in.), %			
Annealed	48	—	—
Hot Rolled	47	14[b]	2[b]
Cold Drawn	12	—	—
Reduction of Area, %			
Annealed	76	—	—
Hot Rolled	75	52	—
Cold Drawn	63	—	—
Hardness (Brinell)			
Annealed	69	—	—
Hot Rolled	83	97–105	97–105
Cold Drawn	142	—	—
Impact Strength (Charpy), ft-lb			
Annealed	19	—	—
Hot Rolled	—	24–28	—
Cold Drawn	—	—	—
Fatigue Strength (endurance limit), 1000 psi			
Annealed	26	—	—
Hot Rolled	28	23	19
Cold Drawn	33	—	—
FABRICATING PROPERTIES			
Annealing Temperature, F	1700–1800	1300–1400	
Forging Temperature Range, F	—	2100–2400	
Bending Temperature Range, F	—	1300–1400	
Machinability Index (AISI B1112 steel=100)	50	50	
Weldability	Readily joined by resistance, arc and gas methods		
CORROSION RESISTANCE	In spite of its purity, ingot iron has corrosion rates much the same as plain carbon steel	Current improved wrought iron has at least 25% greater corrosion resistance than former grade. Shows its greatest advantage over carbon steels in heat transfer equipment handling brines, industrial cooling waters and flue gases. Also used in steam condensate and drainage systems and other elevated temperature equipment	
AVAILABLE FORMS	Sheet and strip, wire, rail sections	Tubular products, plate, sheet, bars, structural shapes, wire, chain	
USES	Deep drawn parts, enameling stock, third rails, wire for electrical apparatus	Condensers and heat exchangers; piping for steam condensates, fresh and salt water, coolants, caustics; processing equipment; plates used for tanks, stacks, exhausts and breechings; bars for curing racks, manhole ladder steps, etc.	

[a] As rolled. [b] In 8 in.

Low and Medium Carbon Steels—Wrought

AISI Type ➔	C1010, C1015	C1018	C1020, C1025	C1030, C1035
COMPOSITION, %	C 0.08–0.18, Mn 0.30–0.60, P 0.040 max, S 0.050 max	C 0.15–0.20, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.18–0.28, Mn 0.30–0.60, P 0.040 max, S 0.050 max	C 0.28–0.38, Mn 0.60–0.90, P 0.040 max, S 0.050 max
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.283	0.283	0.283	0.283
Melting Temp Range, F	2750–2775	2750–2775	2750–2775	2700–2750
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.4×10^{-6}	8.4×10^{-6}	8.4×10^{-6}	8.3×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	14.3	14.3	14.3	19
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension, psi	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$
Ten Str, 1000 psi				
Hot Rolled	51, 61	69	65, 67	80, 85
Cold Worked	56, 74	82	78, 80	85, 92
Yld Str, 1000 psi				
Hot Rolled	29, 46	48	43, 45	50, 54
Cold Worked	33, 62	70	66, 68	72, 79
Elong (in 2 in.), %				
Hot Rolled	38, 39	38	36, 36	30, 30
Cold Worked	35, 24	20	20, 20	26, 25
Red. of Area, %				
Hot Rolled	70, 61	62	59, 58	56, 53
Cold Worked	65, 57	57	55, 55	51, 50
Hardness (Brinell)				
Hot Rolled	101, 126	143	143, 143	163, 183
Cold Worked	113, 143	163	156, 163	179, 201
Impact Str	Markedly dependent on section size and processing details, such as deoxidation practice, rolling practice, etc.—more so than other mechanical properties			
Fatigue Str	Dependent on thermal and mechanical history, though not to the extent that impact strengths are. Conservative estimate of fatigue strength is 40–50% of tensile strength			
THERMAL TREATMENT[a]				
Annealing Temp, F	1650–1750	1650–1750	1650–1750, 1600–1700	1550–1700, 1500–1650
Hardening Temp, F	1650–1700[c]	1650–1700[c]	1600–1675[d]	1575–1650, 1525–1600[e]
Tempering Temp, F	300–1350	300–1350	300–1350	300–1350
FABRICATING PROPERTIES[a]				
Machinability Index[b]				
Hot Rolled	40, 50	52	50, 50	—, —
Cold Worked	45, 58	65	60, 60	67, 67
Weldability	Easily welded by all commercial welding procedures, including gas, arc, bronze, thermit, oxy-acetylene and submerged-melt processes. Preheat and postheat treatments sometimes necessary			
CORROSION RESISTANCE	Rusted by oxygen and water at room temperature, rate of attack increasing sharply as pH goes above 4 and decreasing below pH of 8. Dilute salt solutions increase corrosion rate. Attacked by acids, in general, but satisfactorily resistant to alkalis at normal temperatures. Corrosion rate in ordinary rusting not appreciably affected by carbon or alloy content or by cold working			
AVAILABLE FORMS	Can be obtained in all standard mill forms			
USES	Automobile spiders, gears, clutch disks, bolts, bearing races, camshafts, crankshafts, piston pins, cams, pneumatic tool cylinders, gun blocks, bushings, stud and collar bolts, shifter shoes, draw bars, pivot pins, cap screws, precision shafting, scythe blade heels, flanges, shackles, tie rods, drag links, steering gear connecting rods, thrust washers, wrenches			Brake shoe parts, gears, tie rods, clutch pedals, pitman arms, flywheel rings, crankshafts, camshafts, wheel hubs, tools, springs

[a] Where two values are given, they are for the two grades in that column.
[b] Based on AISI B1112 steel = 100.
[c] Quench in water, brine or caustic frequently used.
[d] Soluble oil solution used for hardening bolts; mineral oil used when quenching for machinability.
[e] Quenched in oil, water, or brine or caustic solutions.

Medium and High Carbon Steels—Wrought

AISI Type ➔	C1040, C1045	C1055, C1060	C1070, C1080	C1095
COMPOSITION, %	C 0.37–0.50, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.50–0.65, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.65–0.88, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.90–1.05, Mn 0.30–0.50, P 0.040 max, S 0.050 max
PHYSICAL PROPERTIES				
Density, lb/cu in	0.283	0.283	0.283	0.283
Melting Temp Range, F	2700–2750	—	—	—
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.3×10^{-6}	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	19	18	18	18
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension, psi	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$
Ten Str, 1000 psi				
Annealed (1450 F)	100, 103[i]	97, 105	112, 119	100
Hot Rolled	91, 98	109, 116	128, 141	142
Hard. & Temp	113[c], 120[d]	150[e], 160[e]	174[f], 189[f]	180[g]
Yld Str, 1000 psi				
Annealed	88, 90[i]	52, 54	60, 66	53
Hot Rolled	58, 59	65, 70	77, 84	84
Hard. & Temp	86[c], 90[c]	105, 112	127, 142	118
Elong (in 2 in.), %				
Annealed	17, 14[i]	24, 20	17, 15	21
Hot Rolled	27, 24	19, 17	15, 12	9
Hard. & Temp	23[c], 18[c]	14, 12	13, 14	11
Red. of Area, %				
Annealed	42, 40[i]	47, 44	34, 22	42
Hot Rolled	50, 45	38, 36	27, 17	18
Hard. & Temp	62[c], 52[d]	45, 40	37, 34	30
Hardness (Brinell)				
Annealed	207, 217[i]	185, 192	207, 223	197
Hot Rolled	201, 212	235, 241	267, 293	293
Hard. & Temp	235[c], 277[d]	307, 321	354, 388	375
Impact Str (Izod), ft-lb				
Annealed	Markedly dependent on section size and processing details	22, 15	11, 6	5
Hot Rolled		18, 13	9, 5	3
Hard. & Temp		22, 15	13, 10	5
THERMAL TREATMENT[a]				
Normalizing Temp, F	—	1525–1650	1525–1650	1525–1650
Annealing Temp, F	1450–1600	1500–1575	1500–1575	1500–1575
Hardening Temp, F	1475–1575[h]	1450–1550	1450–1525	1430–1500
Tempering Temp, F	300–1350	400–1300	400–1300	400–1300
FABRICATING PROPERTIES[a]				
Hot Working Temp Range, F	—	1550–1650	1550–1650	1550–1650
Machinability Index (annealed)[b]	65, 60[i]	55, 53	45, 44	43
Weldability	Easily welded; preheat and postheat treatments necessary	High carbon content introduces difficulties in welding. Thermit process satisfactory; gas and arc methods difficult		
CORROSION RESISTANCE	Rust when brought into contact with moisture and air at room temperature; rates not appreciably affected by carbon content. If salts are present, corrosion rate increases. Attacked readily by acids; resistant to alkalis at ordinary temperatures			
AVAILABLE FORMS	All mill forms	Cold rolled strip, hot rolled strip, flat bars, forgings		
USES	Brake shoe parts, gears, tie rods, clutch pedals, crankshafts, camshafts	Heavy machine parts such as shafts, braces and control rods; hand tools such as wrenches, hammers, pliers, screwdrivers, hatchets and axes; agricultural machinery parts such as plowshares, disks for harrows and mower knives; and flat and helical springs		

[a] Where two values are given, they correspond to the two alloys listed in that column. [b] Based on AISI B1112 steel = 100.
[c] 1-in. round, water quenched 1525 F, drawn at 1000 F. [d] 1-in. round, water quenched 1550 F, tempered at 1000 F.
[e] 1-in. round, normalized 1650 F, reheated to 1550 F, oil quenched, tempered 700 F.
[f] 1-in. round, normalized 1650 F, reheated to 1525 F, oil quenched, tempered 700 F.
[g] 1-in. round, normalized 1650 F, reheated to 1475 F, oil quenched, tempered 700 F.
[h] Quenched in oil, water, or brine or caustic solutions. [i] Cold worked.

Free-Cutting Steels—Wrought

AISI Type[a] →	B1111, C1211	B1112, C1212	B1113, C1213
COMPOSITION, %	C 0.13 max, Mn 0.60–0.90, P 0.07–0.12, S 0.08–0.15	C 0.13 max, Mn 0.70–1.00, P 0.07–0.12, S 0.16–0.23	C 0.13 max, Mn 0.70–1.00, P 0.07–0.12, S 0.24–0.33
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.283	0.283	0.283
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.4×10^{-6}	8.4×10^{-6}	8.4×10^{-6}
Specific Heat, Btu/lb/°F	0.10–0.11	0.10–0 11	0.10–0.11
Electrical Resistivity (68 F), microhm-cm	14.3	14.3	14.3
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	29×10^6	29×10^6	29×10^6
Tensile Strength, 1000 psi[c]			
5/16-In. Dia	85–110	85–110	85–110
1-In. Dia	80–105	80–105	80–105
2-In. Dia	70–90	70–90	70–90
Yield Strength, 1000 psi[c]			
5/16-In. Dia	75–100	75–100	75–100
1-In. Dia	70–90	70–90	70–90
2-In. Dia	60–85	60–85	60–85
Elongation (in 2 in.), %[c]			
5/16-In. Dia	10–20	10–20	10–20
1-In. Dia	12–22	12–22	12–22
2-In. Dia	10–20	10–20	10–20
Reduction of Area, %[c]			
5/16-In. Dia	30–50	30–50	30–50
1-In. Dia	35–55	35–55	35–55
2-In. Dia	30–50	30–50	30–50
Hardness (Brinell)[c]			
5/16-In. Dia	B90–102[b]	B90–102[b]	B90–102[b]
1-In. Dia	163–229	163–229	163–229
2-In. Dia	149–202	149–202	149–202
Impact Strength	Relatively low impact strength at low temperatures; should not be used for shock loading applications at subzero temperatures		
Fatigue Strength	Notch sensitive as cold drawn. Polished fatigue specimens will show expected values but poor finishing or processing of parts may cause low and erratic results for finished parts under dynamic or alternating stresses of relatively low intensity		
THERMAL TREATMENT			
Case Hardening	Case hardened for high surface hardness and good wear resistance where core properties not important Case hardness Rockwell C60–65		
Case Hardening Temp, F[d]	1450–1700	1450–1700	1450–1700
Tempering Temp, F	300	300	300
FABRICATING PROPERTIES			
Workability	Not recommended for operations involving cold metal movement, such as crimping, forming or bending		
Machinability Index[e]	90	100	125
Machining Speed (avg), sfm	153	170	213
AVAILABLE FORMS	Cold drawn shapes		
USES	Studs, nuts, fasteners, sleeves, collars, spacers, dowels, rods, handles, levers		

[a] B1111, B1112, B1113 are bessemer steels. C1211, C1212, C1213 are basic open hearth steels.
[b] Rockwell hardness.
[c] Cold drawn.
[d] Quench in water or oil
[e] Based on AISI B1112 Steel = 100.

Nitriding Steels—Wrought

Type ➔	135	135, Modified	N	EZ	5 Ni-2 Al
COMPOSITION, %	C 0.30–0.40, Mn 0.40–0.70, Si 0.20–0.40, Cr 0.90–1.40, Al 0.85–1.20, Mo 0.15–0.25	C 0.38–0.45, Mn 0.40–0.70, Si 0.20–0.40, Cr 1.40–1.80, Al 0.85–1.20, Mo 0.30–0.45	C 0.20–0.27, Mn 0.40–0.70, Si 0.20–0.40, Cr 1.00–1.50, Al 0.85–1.20, Mo 0.20–0.30, Ni 3.25–3.75	C 0.30–0.40, Mn 0.50–1.10, Si 0.20–0.40, Cr 1.00–1.50, Al 0.85–1.20, Mo 0.15–0.25, Se 0.15–0.25	C 0.20–0.25, Mn 0.25–0.45, Si 0.20–0.30, Ni 4.75–5.25, Cr 0.40–0.60, Mo 0.20–0.30, Al 1.80–2.20, V 0.08–0.15
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.283	0.283	0.283	—
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	30	30	30	30	—
Coef of Ther Exp (32–932 F), per °F	6.5×10^{-6}	6.5×10^{-6}	6.5×10^{-6}	6.5×10^{-6}	—
Spec Ht, Btu/lb/°F	0.11–0.12	0.11–0.12	0.11–0.12	0.11–0.12	—
Elec Res (68 F), microhm-cm	27–29	27–29	27–29	27–29	—
Magnetic?	Yes	Yes	Yes	Yes	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	$29–30 \times 10^{6}$	$29–30 \times 10^{6}$	$29–30 \times 10^{6}$	$29–30 \times 10^{6}$	$29–30 \times 10^{6}$
Ten Str (hard. & temp), 1000 psi	138[a], 121[b]	159[a], 145[b]	132[c], 190[d]	126[a]	206[e]
Yld Str (hard. & temp), 1000 psi	120[a], 103[b]	141[a], 125[b]	114[c], 180[d]	90[a,f]	202[e]
Elong (in 2 in., hard. & temp), %	20[a], 23[b]	18[a], 20[b]	22[c], 15[d]	17[a]	15[e]
Red. of Area (hard. & temp), %	58[a], 62[b]	56[a], 64[b]	59[c], 43[d]	44[a]	46.5[e]
Hardness (Brinell, hard. & temp)	280[a], 230[b]	320[a], 285[b]	277[c], 415[d]	255[a]	44[e,i]
	Cases produced by nitriding these steels will have hardnesses of about Rockwell 15N 94–95, excepting case on Nitralloy N which will be about Rockwell 15N 92–93				
Impact Str (Izod, hard. & temp), ft-lb	65[a], 80[b]	—	—	—	14[e,j]
Endurance Limit, 1000 psi	—	45[g1], 24[g2], 90[g3], 80[g4]	—	—	90[e,k]
THERMAL TREATMENT					
Annealing Temp, F	1650–1700	1650–1700	1500–1550[h]	1650–1700	—
Normalizing Temp, F	—	—	—	—	1700
Quenching Temp, F	1700–1750	1700–1750	1625–1675	1700–1750	1650
Tempering Temp, F	1100–1300	1100–1300	1100–1300	1100–1300	—
Solution Treating Temp, F	—	—	—	—	1275
Aging (8 hr min) Temp, F	—	—	—	—	1050
Nitriding Temp, F	930–1050 for periods ranging to 100 hr; 24 to 48-hr treatments are most widely used				
FABRICATING PROPERTIES					
Hot Working Temp Range, F	1950–2200	1950–2200	1950–2200	1950–2200	1950–2200
Weldability	Can be welded by atomic hydrogen process using Nitralloy welding rod; also flash welding				Can be welded with AWS ER310 stainless welding rod
CORROSION RESISTANCE	Provided the outer skin or white layer is not removed, the nitrided case is resistant to alkalis, crude oil natural gas combustion products, tap water and unagitated salt water. Case is attacked by mineral acids. Removal of white layer greatly reduces resistance to attack				
USES	Most uses based on resistance to wear. Cylinder liners and barrels in aircraft engines, bushings, shafts, piston pins, spindles and thread guides, cams and camshafts, rubber and paper mill rolls. 5 Ni–2 Al recommended where highest core strength is required for heavily loaded wear resistant parts such as gears, bearings, shafts				

[a] Core properties; oil quenched from 1700 F, tempered at 1200 F.
[b] Core properties; oil quenched from 1700 F, tempered at 1300 F.
[c] Core properties; oil quenched from 1650 F, tempered at 1200 F before nitriding.
[d] Core properties; oil quenched from 1650 F, tempered at 1200 F after nitriding.
[e] Core properties; solution treated at 1275 F, aged 8 hr min at 1050 F.
[f] Proportional limit.
[g] Heat treated to 269 Bhn and tested (g1) unnitrided, unnotched; (g2) unnitrided with V notch; (g3) nitrided, unnotched; (g4) nitrided with V notch
[h] Must be cooled rapidly below 1150 F to avoid precipitation hardening.
[i] Rockwell C. [j] Charpy V notch. [k] Polished.

Low Alloy Steels and H Steels—Wrought

COMPOSITION *

AISI Type ↓	C	Mn	Ni	Cr	Mo
13XX					
1330	0.28–0.33, 0.27–0.33	1.00–1.90, 1.45–2.05	—, —	—, —	—, —
1335	0.33–0.38, 0.32–0.38	1.60–1.90, 1.45–2.05	—, —	—, —	—, —
1340	0.38–0.43, 0.37–0.44	1.60–1.90, 1.45–2.05	—, —	—, —	—, —
1345	0.43–0.48, —	1.60–1.90, —	—, —	—, —	—, —
23XX, 25XX					
2317	0.15–0.20, —	0.40–0.60, —	3.25–3.75, —	—, —	—, —
2515	0.12–0.17, 0.12–0.18	0.40–0.60, 0.30–0.70	4.75–5.25, 4.70–5.30	—, —	—, —
2517	—, 0.14–0.20	—, 0.30–0.70	—, 4.70–5.30	—, —	—, —
E2517	0.15–0.20, —	0.45–0.60, —	4.75–5.25, —	—, —	—, —
31XX, 33XX					
3120	0.17–0.22, 0.17–0.23	0.60–0.80, 0.50–0.90	1.10–1.40, 1.00–1.45	0.55–0.75, 0.45–0.85	—, —
3130	0.28–0.33, 0.27–0.33	0.60–0.80, 0.50–0.90	1.10–1.40, 1.00–1.45	0.55–0.75, 0.45–0.85	—, —
3135	0.33–0.38, 0.32–0.38	0.60–0.80, 0.50–0.90	1.10–1.40, 1.00–1.45	0.55–0.75, 0.45–0.85	—, —
3140	0.38–0.43, 0.37–0.44	0.70–0.90, 0.60–1.00	1.10–1.40, 1.00–1.45	0.55–0.75, 0.45–0.85	—, —
3310	—, 0.07–0.13	—, 0.30–0.70	—, 3.20–3.80	—, 1.30–1.80	—, —
E3310	0.08–0.13, —	0.45–0.60, —	3.25–3.75, —	1.40–1.75, —	—, —
3316	—, 0.13–0.19	—, 0.30–0.70	—, 3.20–3.80	—, 1.30–1.80	—, —
E3316	0.14–0.19, —	0.45–0.60, —	3.25–3.75, —	1.40–1.75, —	—, —
40XX					
4023	0.20–0.25, —	0.70–0.90, —	—, —	—, —	0.20–0.30, —
4024	0.20–0.25, —	0.70–0.90, —	—, —	—, —	0.20–0.30, —
4027	0.25–0.30, —	0.70–0.90, —	—, —	—, —	0.20–0.30, —
4028	0.25–0.30, —	0.70–0.90, —	—, —	—, —	0.20–0.30, —
4032	0.30–0.35, 0.29–0.35	0.70–0.90, 0.60–1.00	—, —	—, —	0.20–0.30, 0.20–0.30
4037	0.35–0.40, 0.34–0.41	0.70–0.90, 0.60–1.00	—, —	—, —	0.20–0.30, 0.20–0.30
4042	0.40–0.45, 0.39–0.46	0.70–0.90, 0.60–1.00	—, —	—, —	0.20–0.30, 0.20–0.30
4047	0.45–0.50, 0.44–0.51	0.70–0.90, 0.60–1.00	—, —	—, —	0.20–0.30, 0.20–0.30
4053	0.50–0.56, 0.49–0.56	0.75–1.00, 0.65–1.10	—, —	—, —	0.20–0.30, 0.20–0.30
4063	0.60–0.67, 0.59–0.69	0.75–1.00, 0.65–1.10	—, —	—, —	0.20–0.30, 0.20–0.30
4068	0.63–0.70, 0.62–0.72	0.75–1.00, 0.65–1.10	—, —	—, —	0.20–0.30, 0.20–0.30
41XX					
4118	0.18–0.23, 0.17–0.23	0.70–0.90, 0.60–1.00	—, —	0.40–0.60, 0.30–0.70	0.08–0.15, 0.08–0.15
4130	0.28–0.33, 0.27–0.33	0.40–0.60, 0.30–0.70	—, —	0.80–1.10, 0.75–1.20	0.15–0.25, 0.15–0.25
4135	0.33–0.38, 0.32–0.38	0.70–0.90, 0.60–1.00	—, —	0.80–1.10, 0.75–1.20	0.15–0.25, 0.15–0.25
4137	0.35–0.40, 0.34–0.41	0.70–0.90, 0.60–1.00	—, —	0.80–1.10, 0.75–1.20	0.15–0.25, 0.15–0.25
4140	0.38–0.43, 0.37–0.44	0.75–1.00, 0.65–1.10	—, —	0.80–1.10, 0.75–1.20	0.15–0.25, 0.15–0.25
4142	0.40–0.45, 0.39–0.46	0.75–1.00, 0.65–1.10	—, —	0.80–1.10, 0.75–1.20	0.15–0.25, 0.15–0.25
4145	0.43–0.48, 0.42–0.49	0.75–1.00, 0.65–1.10	—, —	0.80–1.10, 0.75–1.20	0.15–0.25, 0.15–0.25
4147	0.45–0.50, 0.44–0.51	0.75–1.00, 0.65–1.10	—, —	0.80–1.10, 0.75–1.20	0.15–0.25, 0.15–0.25
4150	0.48–0.53, 0.47–0.54	0.75–1.00, 0.65–1.10	—, —	0.80–1.10, 0.75–1.20	0.15–0.25, 0.15–0.25
43XX, 46XX					
4320	0.17–0.22, 0.17–0.23	0.45–0.65, 0.40–0.70	1.65–2.00, 1.55–2.00	0.40–0.60, 0.35–0.65	0.20–0.30, 0.20–0.30
4337	0.35–0.40, 0.34–0.41	0.60–0.80, 0.55–0.90	1.65–2.00, 1.55–2.00	0.70–0.90, 0.65–0.95	0.20–0.30, 0.20–0.30
E4337	0.35–0.40, —	0.65–0.85, —	1.65–2.00, —	0.70–0.90, —	0.20–0.30, —
4340	0.38–0.43, 0.37–0.44	0.60–0.80, 0.55–0.90	1.65–2.00, 1.55–2.00	0.70–0.90, 0.65–0.95	0.20–0.30, 0.20–0.30
E4340	0.38–0.43, 0.37–0.44	0.65–0.85, 0.60–0.95	1.65–2.00, 1.55–2.00	0.70–0.90, 0.65–0.95	0.20–0.30, 0.20–0.30
4608	0.06–0.11, —	0.25–0.45, —	1.40–1.75, —	—, —	0.15–0.25, —
4615	0.13–0.18, —	0.45–0.65, —	1.65–2.00, —	—, —	0.20–0.30, —
4617	0.15–0.20, —	0.45–0.65, —	1.65–2.00, —	—, —	0.20–0.30, —
4620	0.17–0.22, 0.17–0.23	0.45–0.65, 0.35–0.75	1.65–2.00, 1.55–2.00	—, —	0.20–0.30, 0.20–0.30
4621	0.18–0.23, 0.17–0.23	0.70–0.90, 0.60–1.00	1.65–2.00, 1.55–2.00	—, —	0.20–0.30, 0.20–0.30
4640	0.38–0.43, 0.37–0.44	0.60–0.80, 0.50–0.90	1.65–2.00, 1.55–2.00	—, —	0.20–0.30, 0.20–0.30
47XX, 48XX					
4720	0.17–0.22, 0.17–0.23	0.50–0.70, 0.45–0.75	0.90–1.20, 0.85–1.25	0.35–0.55, 0.30–0.60	0.15–0.25, 0.15–0.25
4812	0.10–0.15, 0.09–0.15	0.40–0.60, 0.30–0.70	3.25–3.75, 3.20–3.80	—, —	0.20–0.30, 0.20–0.30
4815	0.13–0.18, 0.12–0.18	0.40–0.60, 0.30–0.70	3.25–3.75, 3.20–3.80	—, —	0.20–0.30, 0.20–0.30
4817	0.15–0.20, 0.14–0.20	0.40–0.60, 0.30–0.70	3.25–3.75, 3.20–3.80	—, —	0.20–0.30, 0.20–0.30
4820	0.18–0.23, 0.17–0.23	0.50–0.70, 0.40–0.80	3.25–3.75, 3.20–3.80	—, —	0.20–0.30, 0.20–0.30

* Phosphorus and sulfur contents usually range between 0.025 and 0.040% for low alloy steels. Silicon content usually ranges between 0.20 and 0.35%. All steels except those prefixed by an "E" are open hearth; "E" steels are electric furnace. The two sets of ranges are for standard low alloy steels and H steels, respectively, and apply to bar, billets and blooms not exceeding 200 sq in. in cross-sectional area.

Low Alloy Steels and H Steels—Wrought

COMPOSITION [a] (continued)

AISI Type ↓	C	Mn	Ni	Cr	Mo
50XX, 51XX					
5015	0.12–0.17, —	0.30–0.50, —	—, —	0.30–0.50, —	—, —
5046	0.43–0.50, 0.43–0.50	0.75–1.00, 0.65–1.10	—, —	0.20–0.35, 0.13–0.43	—, —
5117	0.15–0.20, —	0.70–0.90, —	—, —	0.70–0.90, —	—, —
5120	0.17–0.22, 0.17–0.23	0.70–0.90, 0.60–1.00	—, —	0.70–0.90, 0.60–1.00	—, —
5130	0.28–0.33, 0.27–0.33	0.70–0.90, 0.60–1.00	—, —	0.80–1.10, 0.75–1.20	—, —
5132	0.30–0.35, 0.29–0.35	0.60–0.80, 0.50–0.90	—, —	0.75–1.00, 0.65–1.10	—, —
5135	0.33–0.38, 0.32–0.38	0.60–0.80, 0.50–0.90	—, —	0.80–1.05, 0.70–1.15	—, —
5140	0.38–0.43, 0.37–0.44	0.70–0.90, 0.60–1.00	—, —	0.70–0.90, 0.60–1.00	—, —
5145	0.43–0.48, 0.42–0.49	0.70–0.90, 0.60–1.00	—, —	0.70–0.90, 0.60–1.00	—, —
5147	0.45–0.52, 0.45–0.52	0.70–0.95, 0.60–1.05	—, —	0.85–1.15, 0.80–1.25	—, —
5150	0.48–0.53, 0.47–0.54	0.70–0.90, 0.60–1.00	—, —	0.70–0.90, 0.60–1.00	—, —
5152	0.48–0.55, 0.48–0.55	0.70–0.90, 0.60–1.00	—, —	0.90–1.20, 0.85–1.30	—, —
5155	0.50–0.60, —	0.70–0.90, —	—, —	0.70–0.90, —	—, —
5160	0.55–0.65, 0.55–0.65	0.75–1.00, 0.65–1.10	—, —	0.70–0.90, 0.60–1.00	—, —
E50100	0.95–1.10, —	0.25–0.45, —	—, —	0.40–0.60, —	—, —
E51100	0.95–1.10, —	0.25–0.45, —	—, —	0.90–1.15, —	—, —
E52100	0.95–1.10, —	0.25–0.45, —	—, —	1.30–1.60, —	—, —
61XX [b]					
6117	0.15–0.20, —	0.70–0.90, —	—, —	0.70–0.90, —	—, —
6120	0.17–0.22, 0.17–0.23	0.70–0.90, 0.60–1.00	—, —	0.70–0.90, 0.60–1.00	—, —
6145	0.43–0.48, 0.42–0.49	0.70–0.90, 0.60–1.00	—, —	0.80–1.10, 0.75–1.20	—, —
6150	0.48–0.53, 0.47–0.54	0.70–0.90, 0.60–1.00	—, —	0.80–1.10, 0.75–1.20	—, —
86XX					
8615	0.13–0.18, —	0.70–0.90, —	0.40–0.70, —	0.40–0.60, —	0.15–0.25, —
8617	0.15–0.20, 0.14–0.20	0.70–0.90, 0.60–0.95	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8620	0.18–0.23, 0.17–0.23	0.70–0.90, 0.60–0.95	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8622	0.20–0.25, 0.19–0.25	0.70–0.90, 0.60–0.95	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8625	0.23–0.28, 0.22–0.28	0.70–0.90, 0.60–0.95	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8627	0.25–0.30, 0.24–0.30	0.70–0.90, 0.60–0.95	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8630	0.28–0.33, 0.27–0.33	0.70–0.90, 0.60–0.95	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8635	0.33–0.38, 0.32–0.38	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8637	0.35–0.40, 0.34–0.41	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8640	0.38–0.43, 0.37–0.44	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8641 [c]	0.38–0.43, 0.37–0.44	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8642	0.40–0.45, 0.39–0.46	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8645	0.43–0.48, 0.42–0.49	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8650	0.48–0.53, 0.47–0.54	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8653	0.50–0.56, 0.49–0.56	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.50–0.80, 0.50–0.85	0.15–0.25, 0.15–0.25
8655	0.50–0.60, 0.50–0.60	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8660	0.55–0.65, 0.55–0.65	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
87XX, 92XX					
8715	0.13–0.18, —	0.70–0.90, —	0.40–0.70, —	0.40–0.60, —	0.20–0.30, —
8717	0.15–0.20, —	0.70–0.90, —	0.40–0.70, —	0.40–0.60, —	0.20–0.30, —
8720	0.18–0.23, 0.17–0.23	0.70–0.90, 0.60–0.95	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.20–0.30, 0.20–0.30
8735	0.33–0.38, —	0.75–1.00, —	0.40–0.70, —	0.40–0.60, —	0.20–0.30, —
8740	0.38–0.43, 0.37–0.44	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.20–0.30, 0.20–0.30
8742	0.40–0.45, 0.39–0.46	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.20–0.30, 0.20–0.30
8750	0.48–0.53, 0.47–0.54	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.20–0.30, 0.20–0.30
9255 [d]	0.50–0.60, —	0.70–0.95, —	—, —	—, —	—, —
9260 [d]	0.55–0.65, 0.55–0.65	0.70–1.00, 0.65–1.10	—, —	—, —	—, —
9261 [d]	0.55–0.65, 0.55–0.65	0.75–1.00, 0.65–1.10	—, —	0.10–0.25, 0.05–0.35	—, —
9262 [d]	0.55–0.65, 0.55–0.65	0.75–1.00, 0.65–1.10	—, —	0.25–0.40, 0.20–0.50	—, —
93XX, 98XX					
9310	—, 0.07–0.13	—, 0.40–0.70	—, 2.95–3.55	—, 1.00–1.45	—, 0.08–0.15
E9310	0.08–0.13, —	0.45–0.65, —	3.00–3.50, —	1.00–1.40, —	0.08–0.15, —
E9314	0.11–0.17, —	0.40–0.70, —	3.00–3.50, —	1.00–1.40, —	0.08–0.15, —
9840	0.38–0.43, 0.37–0.44	0.70–0.90, 0.60–0.95	0.85–1.15, 0.80–1.20	0.70–0.90, 0.65–0.95	0.20–0.30, 0.20–0.30
9845	0.43–0.48, —	0.70–0.90, —	0.85–1.15, —	0.70–0.90, —	0.20–0.30, —
9850	0.48–0.53, 0.47–0.54	0.70–0.90, 0.60–0.95	0.85–1.15, 0.80–1.20	0.70–0.90, 0.65–0.95	0.20–0.30, 0.20–0.30

[a] Phosphorus and sulfur contents usually range between 0.025 and 0.040% for low alloy steels. Silicon content usually ranges between 0.20 and 0.35%. All steels except those prefixed by an "E" are open hearth; "E" steels are electric furnace. The two sets of ranges are for standard low alloy steels and H steels, respectively, and apply to bar, billets and blooms not exceeding 200 sq in. in cross-sectional area.
[b] These types contain the following amounts of vanadium: 6117 0.10 min, 6120 0.10 min, 6145 0.15 min and 6150 0.15% min.
[c] Sulfur content is 0.040–0.060%. [d] Silicon content is 1.80–2.20%.

Low Alloy Steels—Wrought

TYPICAL PHYSICAL PROPERTIES [a]

AISI Type →	13XX	23XX	25XX	40XX	41XX	43XX
Melting Temperature, F	—	2600–2620	2610–2620	—	—	2740–2750
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	38.3[c]	34.5–38.5[c]	27	24.7[d]	21.7[c]
Coef of Ther Exp (0–1200 F), per °F	7.9×10^{-6}[b]	8.0×10^{-6}	7.8×10^{-6}	8.3×10^{-6}[b]	—	8.1×10^{-6}
Specific Heat (68–212 F), Btu/lb/°F	0.10–0.11	0.11–0.12	0.11–0.12	0.10–0.11	0.11	0.107
Electrical Resistivity (68 F), microhm-cm	17	28.4[c]	—	19	22.3	30[c]

[a] Density for all low alloy steels is approximately 0.28 lb per cu in. [b] 68–1200 F. [c] 120 F. [d] 68 F.

TYPICAL MECHANICAL PROPERTIES [a]

AISI Type ↓	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong (in 2 in.), %	Red. of Area, %	Hardness, Brinell	Impact Str (Izod), ft-lb
1330[b]	122	100	19	52	248	—
1335[c]	126	105	20	59	262	—
1340[c]	137	118	19	55	285	—
2317[e]	107	72	27	71	222	84
2515[e]	113	94	25	69	233	85
E2517[e]	120	100	22	66	244	80
4023[d]	120	85	20	53	255	—
4032[e]	210	182	11	49	415	—
4042[f]	235	210	10	42	461	—
4053[g]	250	223	12	40	495	—
4063[h]	269	231	8	15	534	—
4130[i]	200	170	16	49	375	25
4140[j]	200	170	15	48	385	16
4150[k]	230	215	10	40	444	12
4320[d]	180	154	15	50	360	32
4337[k]	210	140	14	50	435	18
4340[k]	220	200	12	48	445	16
4615[d]	100	75	18	52	—	42
4620[d]	130	95	21	65	—	68
4640[l]	185	160	14	52	390	25
4815[d]	150	125	18	58	325	44
4817[d]	—	—	15	52	355	36
4820[j]	—	—	13	47	380	28
5120[d]	143	114	13	45	302	6
5130[m]	189	175	13	51	380	—
5140[m]	190	170	13	43	375	16
5150[m]	224	208	10	40	444	—
6120[n]	125	94	21	56	—	28
6145[o]	176	169	16	52	429	20
6150[o]	187	179	13	42	444	13
8620[p]	122	98	21	63	245	76
8630[p]	162	142	14	54	325	42
8640[p]	208	183	13	43	420	18
8650[p]	214	194	12	41	423	—
8720[p]	122	98	21	63	245	76
8740[p]	208	183	13	43	420	18
8750[p]	214	194	12	41	423	—
9255[p]	232[q]	215	9	21	477	6
9261[p]	258[r]	226	10	30	514	12

[a] Properties are for materials hardened and tempered as follows: [b] water quenched from 1525 F, tempered at 1000 F; [c] oil quenched from 1525 F tempered at 1000 F; [d] pseudo-carburized 8 hr at 1700 F, oil quenched, tempered 1 hr at 300 F; [e] water quenched from 1525 F, tempered at 600 F; [f] oil quenched from 1500 F, tempered at 600 F; [g] oil quenched from 1475 F, tempered at 600 F; [h] oil quenched from 1450 F, tempered at 600 F; [i] water quenched from 1550–1600 F, tempered at 800 F; [j] oil quenched from 1550 F, tempered at 800 F; [k] oil quenched from 1525 F, tempered at 800 F; [l] normalized at 1650 F, reheated to 1475 F, oil quenched, tempered at 800 F; [m] normalized at 1625 F, reheated to 1550 F, water quenched, tempered at 800 F; [n] carburized 10 hr at 1680 F, pot cooled, oil quenched from 1525 F, tempered at 300 F; [o] normalized at 1600 F, oil quenched from 1575 F, tempered at 1000 F; [p] oil quenched, tempered at 800 F; [q] normalized at 1650 F, reheated to 1625 F, quenched in agitated oil, tempered at 800 F; [r] normalized at 1600 F, reheated to 1575 F, quenched in agitated oil, tempered at 800 F.

TYPICAL PHYSICAL PROPERTIES [a] (continued)

AISI Type →	46XX	48XX	51XX	61XX	86, 87XX	92, 94XX
Melting Temperature, F	—	2750	2720–2760	—	2745–2755	—
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27[d]	26.0[f]	27–34[g]	27	21.7[c]	27
Coef of Ther Exp (0–1200 F), per °F	6.3×10^{-6e}	8.6×10^{-6}	7.4×10^{-6h}	8.1×10^{-6b}	8.2×10^{-6}	8.1×10^{-6b}
Specific Heat (68–212 F), Btu/lb/°F	0.10–0.11	—	0.10–0.11	0.10–0.11	0.107	0.10–0.12
Electrical Resistivity (68 F), microhm-cm	—	30	21	21	30[c]	19–20

[a] Density for all steels is approximately 0.28 lb per cu in. [b] 68–1200 F. [c] 120 F. [d] 68 F. [e] 0–200 F. [f] 75 F. [g] 32–212 F. [h] 100–518 F.

MACHINABILITY, WELDABILITY, AVAILABILITY, USES [a]

AISI Type ↓	Mach Index[b]	Weldability	Available Forms	Uses
1330 1335 1340	62 62 59	Mn increases crack sensitivity and care must be taken	Billets, bars, forgings	Automotive, farm implements: axles, shafts, bolts, studs, gears, tie rods
2317	55	Good by most commercial procedures	Bar, forgings	Carburized gears, cams
2515 E2517	40 —		Bar, forgings, tubing; also mill forms	Heavy duty carburized parts: aircraft gears, piston pins
4023 4032 4042 4053 4063	73 70 65 56 52	Weldable by procedures used for carbon steels; preheating or postheating sometimes necessary	All standard mill forms	Automotive parts such as countershafts, differential gears, transmission gears and shafts, leaf and coil springs, bolts, axles, steering arms; also hand tools
4130 4140 4150	60 62 45	Weldable by all procedures; difficulty increases with carbon content	All standard mill forms	Arbors, gears, shafts, bushings, axles, aircraft fuselage, bolts, clutch parts, machine tool parts
4320 4337 4340	51 51 51	Readily weldable by oxyacetylene, inert arc and electrical resistance methods	Bar, forgings, tubing, billets; also mill forms	Heavy duty, high strength parts: gears, bearing races, aircraft tubing, shafts, heavy forgings, churn drills
4615 4620	58–60 58–60	Weldable by all procedures	All standard mill forms	Arbors, ball bearings, gears, spindles, camshafts, leaf and coil springs, shovels
4815, 4817, 4820	45	Ordinarily not welded	Billets, bar, tubing, forgings, plate	Heavy duty gears, rock bits, pump parts, sucker rods, machine tools
5120 5130 5140 5150	65 67 60 55	Weldable by oxyacetylene, inert arc and electrical resistance methods	Bar, rod, tubing, forgings, castings	Transmission gears, steering knuckles, side gears, shafts, axles, coil and flat springs
6120 6145 6150	46 27 26	Weldable by all commercial methods	All standard mill forms	Carburized gears, shafts, pistons; springs, axles, pins, connecting rods
8620, 8720 8630 8640, 8740 8650, 8750	57 61 55 45	Weldable by oxyacetylene, inert arc and electrical resistance methods; preheating desirable for grades with more than 0.30% carbon	Usually supplied as bar, forgings, tubing or billet; sometimes in other mill forms	Medium and heavy duty carburized gears, cams, bearing races; also heavy duty bolts, aircraft tubing, hand tools, shafts, forgings
9255 9261	38 36	Not normally recommended	Billets, bar, forgings	Coil and flat springs, axles, chisels, bolts

[a] In general, corrosion resistance of these steels ranges from about the same to slightly better than carbon steels.
[b] Based on AISI B1112 steel = 100.

H Steels—Wrought

END QUENCH HARDENABILITY BAND LIMITS [a]

AISI Type	"J" Distance, in.															
	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2
13XX																
1330 H[b]	56-47	53-40	50-31	45-26	42-23	39-21	37 max	35 max	34 max	33 max	32 max	31 max	31 max	31 max	30 max	30 max
1335 H[c]	57-49	55-44	52-34	48-29	44-26	41-24	39-22	37-21	35-20	34 max	33 max	32 max	31 max	31 max	30 max	30 max
1340 H[c]	60-52	58-49	56-40	54-33	51-29	48-27	44-25	41-24	39-23	38-23	37-22	36-22	35-21	35-21	34-20	34-20
25XX																
2515 H[d]	44-37	42-30	40-24	37-20	34 max	31 max	29 max	28 max	27 max	26 max	25 max	24 max	24 max	23 max	23 max	22 max
2517 H[d]	46-38	45-31	43-25	41-21	37 max	34 max	32 max	31 max	30 max	29 max	28 max	27 max	27 max	26 max	26 max	25 max
31XX																
3120 H[e]	47-39	42-30	35-23	30-20	28 max	27 max	26 max	25 max	24 max	23 max	23 max	22 max	22 max	21 max	21 max	21 max
3130 H[b]	55-47	52-42	49-34	45-30	41-28	38-25	35-24	34-22	33-21	32-20	32 max	31 max	31 max	31 max	30 max	30 max
3135 H[c]	57-50	55-47	53-41	50-35	48-33	44-30	39-28	37-26	36-25	35-23	34-22	34-20	34 max	34 max	33 max	33 max
3140 H[c]	60-52	59-49	57-45	56-41	54-36	52-33	50-31	48-30	46-29	44-28	43-28	42-27	41-27	40-26	40-26	39-25
33XX																
3310 H[d]	43-36	42-35	42-33	41-31	40-30	40-29	39-28	38-27	37-26	37-26	37-26	36-26	36-25	36-25	35-25	35-25
3316 H[d]	47-39	46-38	46-37	45-35	45-33	45-32	44-32	44-31	44-31	43-31	43-31	43-31	42-31	42-30	42-30	41-30
40XX																
4032 H[b]	54-45	46-29	34-23	29-21	26 max	25 max	24 max	23 max	23 max	22 max	22 max	21 max	21 max	20 max	—	—
4037 H[c]	57-49	51-35	38-26	32-22	29-20	27 max	26 max	25 max	25 max	25 max	25 max	24 max	24 max	24 max	23 max	23 max
4042 H[c]	60-52	55-40	45-29	36-26	33-24	31-23	30-23	29-22	28-22	28-21	28-20	27-20	27 max	27 max	26 max	26 max
4047 H[c]	62-55	58-42	52-32	43-28	38-27	35-26	33-25	32-25	31-24	30-24	30-23	30-23	30-22	29-22	29-21	29-21
4053 H[c]	65-59	62-53	59-38	55-32	47-30	42-29	38-28	36-28	34-27	33-27	33-27	32-26	32-26	32-26	31-25	31-25
4063 H[c]	60 min	65-56	64-39	61-35	57-33	51-32	46-31	43-31	41-30	40-30	39-29	38-29	38-28	37-28	37-27	36-27
4068 H[c]	60 min	59 min	64-45	62-36	58-34	52-33	47-32	44-32	42-31	41-31	40-30	39-30	38-29	38-29	38-28	37-28
41XX																
4118 H[e]	46-36	35-23	28 max	25 max	23 max	21 max	20 max	—	—	—	—	—	—	—	—	—
4130 H[b]	55-46	51-38	47-31	42-27	38-26	35-25	34-24	33-23	32-22	32-21	32-20	31 max	31 max	30 max	30 max	29 max
4135 H[c]	58-50	56-48	55-45	53-40	51-36	49-33	47-31	45-30	44-29	42-28	41-27	40-27	39-27	38-26	38-26	37-26
4137 H[c]	59-51	58-49	57-48	55-43	54-39	52-36	50-34	48-33	46-32	45-31	44-30	43-30	42-30	42-29	41-29	41-29
4140 H[c]	60-53	59-51	58-50	57-47	56-42	55-39	54-37	53-35	52-34	51-33	49-33	48-32	47-32	46-31	45-31	44-30
4142 H[c]	62-55	61-53	61-52	60-50	59-47	58-44	57-41	56-39	55-37	54-36	53-35	53-34	52-34	51-34	51-33	50-33
4145 H[c]	63-55	62-54	61-53	61-52	60-50	59-48	59-45	58-42	57-40	57-38	56-37	55-36	55-35	55-35	55-34	54-34
4147 H[c]	64-57	64-56	63-55	63-54	62-53	62-51	61-48	60-45	59-42	59-40	58-39	57-38	57-37	57-37	56-37	56-36
4150 H[c]	65-59	65-58	65-57	64-56	64-55	63-53	62-50	62-47	61-45	60-43	59-41	59-40	58-39	58-38	58-38	58-38
43XX																
4320 H[e]	47-38	43-32	38-27	34-23	31-21	29-20	27 max	26 max	25 max	25 max	24 max	24 max	24 max	24 max	24 max	24 max
4337 H[c]	59-52	59-52	58-51	58-51	57-50	57-49	57-47	57-46	56-44	56-42	55-41	55-40	55-39	54-39	54-39	53-39
4340 H[c]	60-53	60-53	60-53	60-52	60-52	59-51	58-49	58-48	58-47	57-46	57-45	57-44	57-43	56-42	56-41	56-40
E4340 H[c]	60-53	60-53	60-53	60-53	60-53	60-53	59-52	59-51	58-51	58-50	58-49	57-48	57-47	57-46	57-45	57-44
46XX																
4620 H[e]	45-35	39-24	31 max	27 max	25 max	23 max	22 max	21 max	21 max	20 max	—	—	—	—	—	—
4621 H[e]	47-38	44-30	37-25	32-22	28 max	26 max	25 max	24 max	24 max	23 max	23 max	22 max	22 max	22 max	21 max	21 max
4640 H[c]	60-52	58-50	56-44	53-37	49-32	44-29	41-27	39-27	38-26	37-26	36-26	35-25	35-25	34-25	34-24	33-24
47XX, 48XX																
4720 H[e]	47-39	39-27	32-21	28 max	26 max	24 max	23 max	22 max	21 max	21 max	21 max	20 max	—	—	—	—
4812 H[d]	43-34	41-26	37-21	33 max	29 max	27 max	25 max	24 max	24 max	23 max	23 max	22 max	22 max	21 max	21 max	21 max
4815 H[d]	44-37	42-30	39-24	35-21	31 max	29 max	28 max	27 max	26 max	25 max	24 max	24 max	24 max	23 max	23 max	23 max
4817 H[d]	46-38	44-32	41-27	37-23	33-21	31-20	29 max	28 max	27 max	26 max	25 max	25 max	25 max	25 max	24 max	24 max
4820 H[d]	48-40	46-38	43-31	40-27	37-25	35-23	33-22	31-21	29-20	28-20	28 max	27 max	27 max	26 max	26 max	25 max

[a] Rockwell C hardness value and distance from quenched end of standard end quench hardenability band. Range indicates maximum and minimum values. Steels heat treated as follows: [b] normalized at 1650 F, austenitized at 1600 F; [c] normalized at 1600 F, austenitized at 1550 F; [d] normalized at 1700 F, austenitized at 1550 F; [e] normalized at 1700 F, austenitized at 1700 F.

END QUENCH HARDENABILITY BAND LIMITS [a] (continued)

AISI Type	"J" Distance, in.															
	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2
50XX,51XX																
5046 H[c]	62–55	56–32	46–27	35–25	33–24	32–23	31–22	30–21	29–20	28 max	27 max	26 max	25 max	24 max	23 max	23 max
5120 H[c]	46–34	36–23	30 max	27 max	24 max	22 max	21 max	—	—	—	—	—	—	—	—	—
5130 H[b]	55–46	51–39	47–32	42–28	38–25	36–22	34–20	33 max	32 max	31 max	30 max	29 max	27 max	26 max	25 max	24 max
5132 H[b]	56–47	52–40	48–32	42–27	38–24	36–22	34–20	33 max	32 max	31 max	30 max	29 max	28 max	27 max	26 max	25 max
5135 H[c]	57–49	55–43	52–35	47–30	43–27	40–24	38–22	37–21	36–20	35 max	34 max	33 max	32 max	32 max	31 max	30 max
5140 H[c]	59–52	57–48	54–38	50–33	46–30	43–28	40–27	38–25	37–24	36–23	35–21	34–20	34 max	33 max	33 max	32 max
5145 H[c]	62–55	60–51	58–42	56–35	53–32	50–30	47–29	44–28	42–26	41–25	39–24	38–23	37–22	37–21	36 max	35 max
5147 H[c]	64–56	62–54	61–52	60–45	59–37	58–34	57–32	56–31	55–30	54–29	53–27	52–26	51–25	50–24	49–22	48–21
5150 H[c]	65–58	63–56	61–49	59–38	56–34	53–32	50–31	47–30	45–29	43–28	42–27	41–26	40–25	39–24	39–23	38–22
5152 H[c]	65–58	64–57	63–55	62–51	60–45	59–39	58–37	57–35	56–34	55–32	53–31	51–30	50–29	48–27	47–26	45–25
5160 H[c]	60 min	65–59	64–56	63–47	61–39	59–36	56–35	52–34	48–33	47–32	46–31	45–30	44–29	43–28	43–28	42–27
61XX																
6120 H[c]	47–38	42–29	36–24	33–22	31–21	31–20	30 max	29 max	28 max	28 max	27 max	26 max	25 max	25 max	24 max	23 max
6145 H[b]	63–55	62–54	61–49	59–42	57–38	55–36	52–35	50–33	49–32	48–31	47–30	46–29	45–27	44–26	43–25	42–24
6150 H[b]	65–58	64–56	63–53	61–47	60–41	58–38	55–36	52–35	50–34	48–32	47–31	46–30	45–29	44–27	43–26	42–25
86XX																
8617 H[c]	44–33	38–24	31 max	27 max	25 max	23 max	22 max	21 max	21 max	20 max	—	—	—	—	—	—
8620 H[c]	47–37	41–27	34–21	30 max	28 max	26 max	25 max	24 max	23 max	23 max	23 max	23 max	23 max	22 max	22 max	22 max
8622 H[c]	49–39	44–30	37–24	32–20	30 max	28 max	26 max	25 max	25 max	24 max	24 max	24 max	24 max	24 max	24 max	24 max
8625 H[b]	51–41	46–32	40–27	35–23	32–21	30 max	28 max	27 max	27 max	26 max	26 max	26 max	26 max	25 max	25 max	25 max
8627 H[b]	52–43	48–35	43–29	38–26	34–24	32–22	30–21	29–20	28 max	28 max	28 max	27 max	27 max	27 max	27 max	27 max
8630 H[b]	55–46	52–39	47–32	41–28	37–26	34–24	33–22	31–21	30–21	30–20	29–20	29 max	29 max	29 max	29 max	29 max
8635 H[c]	57–49	55–45	53–39	50–33	46–30	43–28	40–26	37–25	36–24	35–23	34–23	33–23	33–23	33–22	32–22	32–22
8637 H[c]	58–51	57–48	55–42	53–36	49–32	46–30	43–28	40–26	39–25	37–25	36–24	36–24	35–24	35–24	35–23	35–23
8640 H, 8641 H[c]	60–53	59–51	58–46	55–39	52–34	49–31	45–29	42–28	41–26	39–26	38–25	38–25	37–24	37–24	37–24	37–24
8642 H[c]	62–54	61–52	60–48	58–42	55–37	52–33	49–31	46–29	44–28	42–28	41–27	40–27	40–26	39–26	39–26	39–26
8645 H[c]	63–56	63–54	61–50	60–45	58–39	55–35	52–33	49–31	47–30	45–29	43–28	42–28	42–27	41–27	41–27	41–27
8650 H[c]	65–58	64–57	63–54	62–50	60–44	59–39	58–36	56–34	55–33	53–32	52–31	50–31	49–30	47–30	46–29	45–29
8653 H[c]	65–59	65–58	64–57	64–56	63–53	62–47	62–44	61–42	61–40	60–39	59–38	59–37	59–36	59–35	58–35	58–34
8655 H[c]	59 min	58 min	56 min	54 min	65–49	64–43	63–40	62–38	61–37	60–35	59–34	58–34	57–33	56–33	55–32	53–32
8660 H[c]	60 min	60 min	59 min	57 min	53 min	47 min	44 min	65–42	64–40	64–39	63–38	62–37	62–36	61–36	60–35	60–35
87XX																
8720 H[c]	47–38	42–30	35–24	31–21	29 max	27 max	26 max	25 max	24 max	24 max	23 max	23 max	23 max	23 max	22 max	22 max
8740 H[c]	60–53	60–51	58–46	56–40	53–35	50–32	48–31	45–29	43–28	42–28	41–27	40–27	39–27	39–27	38–26	38–26
8742 H[c]	62–55	61–53	60–49	58–44	56–39	53–35	51–33	48–31	46–30	45–29	43–29	42–28	42–28	41–28	41–28	40–27
8750 H[c]	65–59	64–57	63–56	62–53	61–49	60–45	59–42	58–39	57–37	55–35	53–34	52–33	51–33	50–32	49–32	48–32
92XX																
9260 H[b]	60 min	64–53	62–41	58–36	52–35	47–34	43–33	40–32	38–31	37–31	36–30	36–30	35–29	35–29	35–28	34–28
9261 H[b]	60 min	65–59	64–52	63–42	60–37	54–36	45–35	42–34	39–33	38–32	37–31	37–31	36–30	36–30	35–29	35–29
9262 H[b]	60 min	60 min	65–56	64–48	62–39	59–37	55–36	48–35	45–34	43–33	41–33	39–32	38–31	37–31	36–30	36–30
93XX,98XX																
9310 H[d]	43–35	42–34	42–31	41–29	40–27	38–26	36–26	35–26	35–26	35–25	34–25	34–25	34–25	34–25	33–24	33–24
9840 H[c]	60–53	60–53	60–53	60–52	59–51	58–48	58–45	57–43	56–41	55–39	55–38	55–36	54–36	54–35	53–34	53–34
9850 H[c]	65–59	65–59	65–59	65–58	65–58	65–58	64–57	64–56	63–54	62–52	62–50	61–49	61–48	61–47	60–47	60–47

[a] Rockwell C hardness value and distance from quenched end of standard end quench hardenability band. Range indicates maximum and minimum values. Steels heat treated as follows: [b] normalized at 1650 F, austenitized at 1600 F; [c] normalized at 1600 F, austenitized at 1550 F; [d] normalized at 1700 F, austenitized at 1550 F; [e] normalized at 1700 F, austenitized at 1700 F.

Austenitic Stainless Steels—Wrought

AISI Type ➔	201	202
COMPOSITION, %	C 0.15 max, Mn 5.5–7.5, Cr 16.0–18.0, Ni 3.5–5.5, N 0.25 max	C 0.15 max, Mn 7.5–10.0, Cr 17.0–19.0, Ni 4.0–6.0, N 0.25 max
PHYSICAL PROPERTIES		
Density, lb/cu in.	0.28	0.28
Ther Cond (68–212 F), Btu/hr/sq ft/°F/ft	9.4	9.4
Coef of Ther Exp, per °F		
32 to 200 F	8.7×10^{-6}	—
32 to 600 F	9.7×10^{-6}	10.2×10^{-6}
32 to 900 F	10.1×10^{-6}	10.6×10^{-6}
32 to 1400 F	—	11.3×10^{-6}
Specific Heat, Btu/lb/°F	0.12	0.12
Electrical Resistivity (68 F), microhm-cm	69	69
Magnetic?	No	No
Magnetic Permeability (max)	1.02	1.02
MECHANICAL PROPERTIES		
Mod of Elast in Tension, psi	28.6×10^6	28×10^6
Tensile Strength, 1000 psi		
Annealed[a]		
Tested at Rm Temp	115, 114, 95[b]	105, —
Tested at 1200 F	—, 50	—
Tested at 1400 F	27, 37	—
Cold Worked[c]		
Quarter Hard	125	—
Half Hard	150	—
Yield Strength, 1000 psi		
Annealed[a]		
Tested at Rm Temp	55, 53, 47[b]	55, —
Tested at 1200 F	—, 21	—
Tested at 1400 F	—, 19	—
Cold Worked[c]		
Quarter Hard	75	—
Half Hard	110	—
Elongation (in 2 in.), %		
Annealed[a]		
Tested at Rm Temp	55, 57, 60[b]	55, —
Tested at 1200 F	29, 36	—
Tested at 1400 F	29, 38	—
Cold Worked[c]		
Quarter Hard	25	—
Half Hard	15	—
Hardness (Rockwell, annealed)	B90	B90
Rupture Stress (annealed, 1000 hr), 1000 psi		
Tested at 1200 F	22.0	—
Tested at 1400 F	7.0	—
THERMAL TREATMENT		
Annealing Temp, F	1850–2050	1850–2050
FABRICATING PROPERTIES		
Hot Working Temp Range, F	2100–2250	2100–2250
Formability	Moderate; similar to type 301	Good; similar to type 302
Machinability Index[d]	50	50
Weldability	Excellent	Excellent
CORROSION RESISTANCE	Good; similar to type 301	Good; similar to types 302, 304
AVAILABLE FORMS	Sheet, strip, some bar	Rod, bar, sheet, strip, plate
USES	Alternate for type 301	Alternate for type 302

[a] Where two values are given, they represent sheet and bar respectively.
[b] Welded and annealed.
[c] Minimum value for sheet tested at room temperature.
[d] Based on AISI B1112 Steel = 100.

Austenitic Stainless Steels—Wrought

AISI Type →	301	302	303	304, 304L
COMPOSITION, %	C 0.15, Mn 2 max, Si 1 max, P 0.04 max, S 0.03 max, Cr 16–18, Ni 6–8	C 0.15, Mn 2 max, Si 1 max, P 0.04 max, S 0.03 max, Cr 17–19, Ni 8–10	C 0.15 max, Mn 2 max, P, S or Se 0.07 min, Si 1 max, Cr 17–19, Ni 8–10, Mo or Zr 0.60 max	C 0.08 max (304) or 0.03 max (304L), Mn 2 max, Si 1 max, P 0.04 max, S 0.030 max, Cr 18–20, Ni 8–11
PHYSICAL PROPERTIES				
Density, lb/cu in	0.29	0.29	0.29	0.29
Melting Point Range, F	2550–2590	2550–2590	2550–2590	2550–2650
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	9.4	9.4	9.4	9.4
Coef of Ther Exp (32–212 F), per °F	9.4×10^{-6} [a]	9.6×10^{-6}	9.6×10^{-6}	9.6×10^{-6}
Spec Ht (32–212 F), Btu/lb/°F	0.12	0.12	0.12	0.12
Elec Res (68 F), microhm-cm	72	72	72	72
MECHANICAL PROPERTIES[b]				
Mod of Elast in Tension, psi	28.0×10^6	28.0×10^6	28.0×10^6	28.0×10^6
Ten Str, 1000 psi				
Annealed	110, 105, —	90, 90, 85	—, —, 90	85, 85, 85
Cold worked[d]	185, —, —	—, —, 110[c]	—, —, 110[c]	—, —, 110[c]
Yld Str, 1000 psi				
Annealed	40, 40, —	40, 35, 35	—, —, 35	35, 30, 35
Cold Worked[d]	140, —, —	—, —, 75[c]	—, —, 75[c]	—, —, 75[c]
Elong (in 2 in.), %				
Annealed	60, 55, —	50, 60, 60	—, —, 50	50, 60, 60
Cold Worked[d]	8–9, —, —	—, —, 35[c]	—, —, 30[c]	—, —, 60
Red. of Area, %				
Annealed	—, 70, —	—, 70, 70	—, —, 55	—, 70, 70
Cold Worked	—	—, —, 60[c]	—, —, 50[c]	—
Hardness[e]				
Annealed	R_B85, —, —	R_B85, R_B80, 150	—, —, 160	R_B80, 150, 150
Cold Worked	R_B41, —, —	—, —, 240[c]	—, —, 240[c]	—, —, 240[c]
Impact Str (Izod), ft-lb				
Annealed	—, 110, —	—, 110, 110	—, —, 80	—, 110, 110
Cold Worked	—	—	—	—, —, 90[c]
Endurance Limit, 1000 psi				
Annealed	35, 39, —	—, —, 34	—, —, 35	35, 35, 34
Cold Worked	80, —, —	—	—	—
Creep Str (1% ext in 1000 hr), psi				
1000 F	—	17,000	—	17,000
1300 F	—	4,000	—	4,000
1500 F	—	1,200	—	1,200
FABRICATING PROPERTIES				
Annealing Temp, F[f]	1850–2050	1900–2050	1850–2050	1900–2050
Forging Temp (start), F[g]	2100–2300	2100–2300	2100–2350	2100–2300
Machinability Index[h]	—	55	65 of screw stock	50
Weldability	Excellent	Excellent	Poor	Excellent
CORROSION RESISTANCE	Very good atmosphere resistance; slightly less than type 302	Excellent atmosphere resistance; also resists food products, acids and other chemicals	Very good atmosphere resistance; some resistance sacrificed for better machinability	Excellent atmosphere resistance; slightly better than type 302
AVAILABLE FORMS	Sheet, strip, wire	Sheet, strip, plate, bar, wire, tubing	Bar, wire, forgings	Sheet, strip, plate, bar, wire, forgings, tubing
USES	Lightweight, high strength applications; transportation equipment, roof drainage and trim	General purpose	General purpose free-machining grade	General purpose; also welded construction

[a] For 32–600 F range. [b] Where three values are given, they represent sheet, plate and bar in that order.
[c] Cold drawn, high tensile 1⅛-in. dia. bar. [d] Minimum value at full hard temper.
[e] Values are Brinell except where Rockwell scale is noted. [f] Cool rapidly after anneal.
[g] Finish forging all grades at 1700 F or above. [h] Based on AISI B1112 Steel = 100.

continued on next page

Austenitic Stainless Steels—Wrought

AISI Type ➡	305	309, 309S	310, 310S	316, 316L, 316ELC	321
COMPOSITION, %	C 0.12 max, Mn 2 max, P 0.045 max, S 0.030 max, Si 1 max, Cr 17–19, Ni 10–13	C 0.20 max (309), C 0.08 max (309S), Mn 2 max, P 0.04 max, S 0.03 max, Si 1 max, Cr 22–24, Ni 12–15	C 0.25 max (310), C 0.08 max (310S), Mn 2 max, P 0.04 max, S 0.03 max, Si 1.5 max, Cr 24–26, Ni 19–22	C 0.08 max (316), C 0.03 max (316L), Mn 2 max, Si 1 max, P 0.04 max, S 0.03 max, Cr 16–18, Ni 10–14, Mo 2–3	C 0.08 max, Mn 2 max, Si 1 max, P 0.04 max, S 0.03 max, Cr 17–19, Ni 8–11, Ti 5 x C
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.29	0.29	0.29	0.29	0.29
Melting Point Range, F	2550–2590	2550–2650	2550–2650	2500–2550	2550–2600
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	9.4	8	8	9.4	9.3
Coef of Ther Exp (32–600 F), per °F	9.6×10^{-6}	9.3×10^{-6}	9.0×10^{-6}	9.0×10^{-6}	9.5×10^{-6}
Spec Heat (32–212 F), Btu/lb/°F	0.12	0.12	0.12	0.12	0.12
Elec Res (68 F), microhm-cm	72	78	78	74	72
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension, psi	28.0×10^6	29.0×10^6	29.0×10^6	28.0×10^6	28.0×10^6
Ten Str (ann.), 1000 psi	85, 85, —	90, 95, 95	95, 95, 95	90, 85, 80	90, 85, 85
Yld Str (ann.), 1000 psi	38, 38, —	45, 40, 40	45, 45, 45	40, 35, 30	35, 30, 35
Elong (in 2 in., ann.), %	50, 50, —	45, 45, 45	45, 50, 50	50, 55, 60	50, 55, 55
Red. of Area (ann.), %	—, —, —	—, —, 65	—, —, —	—, —, 70	—, —, 65
Hardness (ann.)[b]	R_B80, —, —	R_B85, 170, 160	R_B85, —, R_B89	R_B85, 150, 150	R_B80, 160, 150
Impact Str (Izod, ann.), ft-lb	—, —, —	—, —, 110	—, —, 85	—, —, 110	—, —, 110
Endurance Limit (ann.), 1000 psi	—, —, —	—	—, —, —	39, 39, 38	—, —, 38
Creep Str (1% ext in 10,000 hr), psi					
1000 F	—	15,900	17,000	25,000	18,000
1300 F	—	4,500	5,000	7,900	4,500
1500 F	—	1,000	1,000	2,800	850
FABRICATING PROPERTIES					
Annealing Temp, F	1850–2250	1900–2050	1900–2100	1850–2050	2100–2250
Forging Temp (start), F[c]	2100–2300	2050–2250	2000–2250	2100–2300	2100–2300
Machinability Index[d]	55	50	50	50	55
Weldability	Excellent	Good	Good	Excellent	Excellent
CORROSION RESISTANCE	Excellent atmosphere resistance; slightly better than type 302	Excellent atmosphere resistance; better than type 302. Resists destructive heat scaling up to 2000 F	Excellent atmosphere resistance; better than type 309. Resists scaling to 2100 F	Best of any standard stainless steel. Greater resistance than type 302 to reducing acids, sea water and other corrosive media causing pitting type of corrosion	Excellent atmosphere resistance; similar to type 302. Not subject to carbide precipitation
AVAILABLE FORMS	Sheet, strip, plate, wire	Sheet, strip, plate, bar, wire	Sheet, strip, plate, bar, wire, tubing	Sheet, strip, plate, bar, wire, tubing	Sheet, strip, plate, bar, wire, tubing
USES	Alternate for type 302 where spinning, special drawing and cold heading are required, e.g., fasteners	Heat resisting applications	Heat exchangers, petroleum refining and chemical processing equipment, gas turbines	Processing equipment exposed to severe corrosive media. Stressed parts that operate at high temperatures	Welded equipment used in the unannealed condition and exposed to corrosive conditions. Equipment that must operate in the sensitization range (800–1650 F)

[a] Where three values are given, they represent sheet, plate and bar in that order.
[b] Values are Brinell except where Rockwell scale is noted.
[c] Finish forging in all grades at 1700 F or above.
[d] Based on AISI B1112 Steel = 100.

Ferritic Stainless Steels—Wrought

AISI Type →	405	430	430F	446
COMPOSITION, %[a]	C 0.08, Mn 1.00, Si 1.00, P 0.04, S 0.03, Cr 11.5–14.5, Al 0.10–0.30	C 0.12, Mn 1.00, Si 1.00, P 0.04, S 0.03, Cr 14.0–18.0	C 0.12, Mn 1.25, P 0.06, S 0.15 min, Cr 14.0–18.0	C 0.20, Mn 1.50, Si 1.00, P 0.04, S 0.03, Cr 23.0–27.0, N 0.25
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.28	0.28	0.28	0.27
Melting Temp Range, F	2700–2790	2600–2750	2600–2750	2600–2750
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	—	15.1	15.1	12.1
Coef of Ther Exp (32–212 F), per °F	6.0×10^{-6}	5.8×10^{-6}	5.8×10^{-6}	5.8×10^{-6}
Spec Ht, Btu/lb/°F	0.11	0.11	0.11	0.12
Elec Res (70 F), microhm-cm	60.0	60.0	60.0	67.0
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	29×10^6	29×10^6	29×10^6	29×10^6
Ten Str, 1000 psi				
Annealed	65–70	75	80	80–85
Cold Worked	85	75–90	80–90	85
Yld Str (0.2% offset), 1000 psi				
Annealed	35–40	40–45	55	50–55
Cold Worked	70	45–80	55–80	70
Elong (in 2 In.), %				
Annealed	25–30	25–30	25	20–25
Cold Worked	20	15–25	15–25	20
Red. of Area, %				
Annealed	50–60	60–65	60–65	45
Cold Worked	60	55–65	55–65	45
Hardness (Rockwell)				
Annealed	B75–90	B80	B80	B83–B86
Cold Worked	185[b]	B95	B95	B90
Impact Str (Izod, annealed), ft-lb	25[c]	—	—	2
Creep Str (1%, 1000F), psi				
10,000 Hr	—	8500	8500	6000
100,000 Hr	—	7000	7000	4200
THERMAL TREATMENT				
Annealing Temp, F	1350–1500	1250–1500	1250–1400	1450–1600
FABRICATING PROPERTIES				
Hot Working Temp Range, F	1950–2050	1900–2100	1950–2100	1950–2050
Machinability Index[d]	60	Fair	Excellent	Fair
Weldability	Excellent for fusion welding	Fair; post anneal recommended	Poor	Fair; care required because of high Cr content
CORROSION RESISTANCE	Good resistance to weather, water, some chemicals	Excellent resistance to weather, water; good resistance to most chemicals	Very good resistance to weather, water; some resistance sacrificed for better machinability	High resistance to corrosion and scaling; one of the most oxidation resistant steels commercially available
AVAILABLE FORMS	Bar, plate, sheet	Bar, plate, sheet, strip	Bar	Bar, plate, sheet, strip
USES	Lining for oil stills; weldments where 12% Cr gives sufficient corrosion resistance; turbine blades, annealing boxes, quenching racks	General purpose grade; automobile and other trim, kitchen equipment, chemical equipment (430F is free-machining grade)		High temperature service up to 2150 F. Furnace parts, glass molds, pyrometer tubes, chemical processing equipment

[a] Maximum values unless otherwise stated. [b] Brinell. [c] Minimum. [d] Based on AISI B1112 Steel = 100.

Martensitic Stainless Steels—Wrought

AISI Type →	403, 410	414	416	420	431
COMPOSITION, %	C 0.15 max, Cr 11.5–13.5	C 0.15 max, Cr 11.5–13.0, Ni 1.25–2.5	C 0.15 max, Cr 12–14, P, S or Se 0.07 min, Mo or Zr 0.06 max	C >0.15, Cr 12–14	C 0.20 max, Cr 15–17, Ni 1.25–2.50
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.28	0.28	0.28	0.28	0.28
Melting Point, F	2700–2790	—	2700–2790	2650–2750	2650
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	14.4	14.4	14.4	14.4	11.7
Coef of Ther Exp, per °F					
32–212 F	5.5×10^{-6}	5.8×10^{-6}	5.5×10^{-6}	5.7×10^{-6}	6.5×10^{-6}
32–1200 F	6.5×10^{-6}	—	6.5×10^{-6}	6.8×10^{-6}	—
Spec Ht (32–212 F), Btu/lb/°F	0.11	0.11	0.11	0.11	0.11
Elec Res (rm temp), microhm-cm	57	70	57	55	72
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6
Ten Str, 1000 psi					
Annealed	65–75	115–120	75	95	125
Hard. & Temp	90–190	120–200	90–190	230	125–205
Yld Str, 1000 psi					
Annealed	35–40	90–105	40	50	95
Hard. & Temp	60–145	105–150	60–145	195	90–155
Elong (in 2 in.), %					
Annealed	25–35	15–20	30	25	20
Hard. & Temp	15–30	15–20	12–25	8	15–20
Hardness (Brinell)					
Annealed	155	235	155	195	260
Hard. & Temp	180–390	250–410	180–390	500	260–415
Impact Str (Izod), ft-lb					
Annealed	90	50	70	—	—
Hard. & Temp	35–75	45–50	20–60	10	30–50
Endurance Limit (annealed), 1000 psi	40	45	40	40	45
Creep Str (1% ext in 10,000 hr, annealed), psi					
1000 F	9200	—	9200	—	—
1300 F	1000	—	1000	—	—
THERMAL TREATMENT					
Annealing Temp, F	1500–1650	—	1500–1650	1550–1650	—
Hardening Temp, F	1700–1850	1800–1900	1700–1850	1800–1900	1800–1950
Tempering Temp, F	400–1400	400–1300	400–1400	300–700	400–1200
FABRICATING PROPERTIES					
Machinability Index[a]	55[b]	Fair	80	45[d]	45[d]
Weldability	Fair; small welds can be annealed	Fair[c]	Poor	Fair	Fair[c]
Forging Temp (start), F	2000–2200	2100–2200	2100–2300	2000–2200	2100–2250
CORROSION RESISTANCE	Good resistance to weather and water; also good resistance to some chemicals				
AVAILABLE FORMS	Plate, sheet, strip, bar, tube, rounds, structural and bar shapes, round and flat wire, tubing				
USES	Steam turbine blades, highly stressed parts	Springs, knife blades, tempered rules	Automatic screw machine parts	Cutlery, surgical instruments, ball bearings, magnets	High strength parts, pumps, valves, paper machinery

[a] Based on AISI B1112 Steel = 100. [b] Hardened to 200–220 Bhn. [c] With preheat and postheat. [d] Hardened to 225 Bhn.

Martensitic Stainless Steels—Wrought

AISI Type →	440A	440B	440C	501	502[a]
COMPOSITION, %	C 0.60–0.75, Cr 16–18, Mo 0.75 max	C 0.75–0.95, Cr 16–18, Mo 0.75 max	C 0.95–1.20, Cr 16–18, Mo 0.75 max	C > 0.10, Cr 4–6	C 0.10 max, Cr 4–6
PHYSICAL PROPERTIES					
Density, lb/cu in	0.28	0.28	0.28	0.28	0.28
Melting Point, F	2500–2750	2500–2750	2500–2750	2700–2800	2700–2800
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	14.0	14.0	14.0	21.2	21.2
Coef of Ther Exp, per °F					
32–212 F	5.6×10^{-6}	5.6×10^{-6}	5.6×10^{-6}	6.2×10^{-6}	6.2×10^{-6}
32–1200 F	—	—	—	7.3×10^{-6}	7.3×10^{-6}
Spec Ht (32–212 F), Btu/lb/°F	0.11	0.11	0.11	0.11	0.11
Elec Res (rm temp), microhm-cm	60	60	60	40	40
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6
Ten Str, 1000 psi					
Annealed	105	107	110	70	65–70
Hard. & Temp	260	280	285	115–175	—
Yld Str, 1000 psi					
Annealed	60	62	65	30	25–30
Hard. & Temp	240	270	275	90–135	—
Elong (in 2 in.), %					
Annealed	20	18	14	28	30
Hard. & Temp	5	3	2	15–20	—
Hardness (Brinell)					
Annealed	215	220	230	160	150
Hard. & Temp	510	555	580	240–370	—
Impact Str (Izod), ft-lb					
Annealed	2	2	2	—	85
Hard. & Temp	4	3	2	—	—
Endurance Limit (annealed), 1000 psi	40	40	40	35	35
Creep Str (1% ext in 10,000 hr, annealed), psi					
1000 F	Not used in fatigue applications			9500	9500
1300 F				800	800
THERMAL TREATMENT					
Annealing Temp, F	1550–1650	1550–1650	1550–1650	1525–1600	1525–1600
Hardening Temp, F	1850–1950	1850–1950	1850–1950	1600–1700	—
Tempering Temp, F	300–800	300–800	300–800	400–1400	—
FABRICATING PROPERTIES					
Machinability Index[b]	40	40	40	Fair	Fair
Weldability	Weldable with great care	Weldable with great care	Weldable with great care	Fair	Fair
Forging Temp (start), F	1900–2200	1900–2150	1900–2100	2100–2200	2100–2200
CORROSION RESISTANCE	Good resistance to weather and water; also good resistance to some chemicals				
AVAILABLE FORMS	Plate, sheet, strip, bar, tube, rounds, structural and bar shapes, round and flat wire, tubing				
USES	Instruments, cutlery, valves			Applications requiring heat resistance and good mechanical properties at elevated temperatures; oil refineries	

[a] Generally used in annealed condition only. [b] Based on AISI B1112 Steel = 100.

High Temperature Steels—Wrought

Type →	Martensitic Stainless			Low Alloy	
	422, 1420 WM	1415 NW (Greek Ascoloy)	1430 MV (Lapelloy)	Chromoloy (14 CMV)	17-22AS (14 MV)
COMPOSITION, %	C 0.20, Mn 0.65, Si 0.55, Cr 13.0, Ni 0.75, Mo 0.95, W 1.0, V 0.35, Fe bal	C 0.17, Mn 0.40, Si 0.30, Cr 12.75, Ni 1.95, Mo 0.15, W 3.0, Cu 0.13, Fe bal	C 0.30, Mn 1.05, Si 0.30, Cr 11.80, Ni 0.25, Mo 2.80, V 0.25, Fe bal	C 0.20, Mn 0.50, Si 0.75, Cr 1.0, Mo 1.0, V 0.10, Fe bal	C 0.30, Mn 0.55, Si 0.70, Cr 1.30, Mo 0.50, V 0.25, Fe bal
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.281	0.284	0.281	0.285	0.283
Melting Temp Range, F	2675–2700	2660–2670	2700–2750	—	2700–2750
Ther Cond (800 F), Btu/hr/sq ft/°F/ft	15.8	—	15.8	—	17.3
Coef of Ther Exp (70–1000 F), per °F	6.5×10^{-6}	6.3×10^{-6}	6.5×10^{-6}	7.9×10^{-6}	7.8×10^{-6}
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension, psi					
Room Temp	30×10^6	29×10^6	30×10^6	31.6×10^6	29.5×10^6
1000 F	21.5×10^6	21.5×10^6	22×10^6	25.4×10^6	20×10^6
Ten Str, 1000 psi					
Room Temp	235	170	157	139	150
800 F	221	135	123 (900 F)	119	121
1000 F	—	103	89 (1100 F)	103	91
Yld Str (0.2% offset), 1000 psi					
Room Temp	186	150	125	117	127
800 F	188	122	94 (900 F)	96	101
1000 F	—	98	81 (1100 F)	85	78
Elongation (in 2 in.), %					
Room Temp	10	13.3	12	8 (min)	16.5
800 F	13.5	13.3	10 (900 F)	—	18
1000 F	—	17.1	28 (1100 F)	—	18
Impact Str (Charpy), ft-lb					
Room Temp	19.5	19.5	10.0	—	31
1000 F	38.5	—	15.0	—	37[f]
Fatigue Str (10^7 cycles), 1000 psi					
900 F	45[b]	—	53[d]	—	—
1100 F	32[b]	53 (1000 F)	36[d]	—	—
Rupture Str (1000 F), 1000 psi					
10 Hr	71	48[c]	73[e]	96	95
100 Hr	63	42[c]	65[e]	78	74
1000 Hr	57	36[c]	58[e]	52	55
10,000 Hr	49	31[c]	48[e]	32	31
FABRICATING PROPERTIES					
Hot Working Temp, F	1700–2100	1700–2200	1700–2200	1500–2100	1500–2100
Cold Workability	Fair	Fair	Fair	Good	Good
Machinability	Fair to good	Poor	Fair to good	Good	Good
Weldability	Not recommended	Not recommended	Not recommended	Excellent	Very good
CORROSION RESISTANCE	Resist atmospheric corrosion, weak organic acids and oxidizing acids (such as nitric); do not have the superior resistance to pitting by dilute reducing acids which characterizes the 300 series stainless steels. Good oxidation resistance up to 1450 F			Poor res compared to other alloys covered here; easily and severely pitted in salt spray test; can be protected with paints. Good oxidation resistance up to 1000 F	
AVAILABLE FORMS	Sheet, strip, plate, bar, forgings, tubing			Bar, forgings, plate, sheet, strip	Bar, forgings
USES	Turbine buckets, jet engine compressor blades, etc., requiring high strength at high temperatures				

[a] Properties for materials in the following conditions:
422, 1420 WM: austenitized at 1900 F, oil quenched, tempered 2 hr at 800 F, air cooled; impact and rupture properties: 2 hr at 1200 F.
1415 NW (Greek Ascoloy): austenitized ½ hr at 1800 F, oil quenched, tempered 2 hr at 1050 F, air cooled.
1430 MV (Lapelloy): austenitized at 2000 F, oil quenched, tempered 2 hr at 1200 F, air cooled.
Chromoloy: normalized 1 hr at 1650–1750 F, air cooled, tempered 2 hr at 1200 F, air cooled.
17–22 AS (14 MV): normalized from 1650–1750 F, tempered 6 hr at 1225 F, air cooled.

[b] Austenitized at 1900 F, tempered 4 hr at 1300 F.

[c] Austenitized ½ hr at 1800 F, air cooled, tempered 1½ hr at 1260 F.

[d] Hardened ¾ hr at 2000 F, salt quenched, held ¾ hr at 500 F, air cooled, tempered 4 hr at 1320 F, air cooled.

[e] Austenitized at 2000 F, oil quenched, tempered 2 hr at 1300 F.

[f] Normalized from 1650–1750 F, tempered 6 hr at 1275 F, air cooled.

Ultra High Strength Steels—Wrought

Type ➔	Modified H-11	MX-2	300-M	D-6A
COMPOSITION, %	C 0.40, Mn 0.35, Si 1.0, Cr 5.0, Mo 1.4, V 0.45, Fe bal	C 0.39, Mn 0.70, Si 1.0, Cr 1.10, Mo 0.25, V 0.15, Co 1.0, Fe bal	C 0.40, Mn 0.75, Si 1.60, Ni 1.85, Cr 0.85, Mo 0.40, V 0.08, Fe bal	C 0.46, Mn 0.75, Si 0.22, Ni 0.55, Cr 1.0, Mo 1.0, Fe bal
PHYSICAL PROPERTIES				
Density, lb/cu in	0.281	0.276	—	0.283
Ther Cond (1100 F), Btu/hr/sq ft/°F/ft	16.6	—	—	—
Coef of Ther Exp, per °F	7.4×10^{-6} [b]	5.68×10^{-6} [c]	7.61×10^{-6} [d]	—
MECHANICAL PROPERTIES [a]				
Mod of Elast in Tension, psi				
Room Temp	30×10^6	29.4×10^6	—	30×10^6
400 F	$27.6–27.8 \times 10^6$	—	—	24.4×10^6
800 F	$21.9–26.6 \times 10^6$	—	—	23.7×10^6
Ten Str, 1000 psi				
Room Temp	295–311	279	289	284
500 F	270–281	—	270	267
800 F	252–259	—	232 (700 F)	185 [e]
1000 F	216–220	—	—	139 [f]
Yld Str (0.2% offset), 1000 psi				
Room Temp	241–247	239	242	250
500 F	220–221	—	200	188
800 F	199–207	—	178 (700 F)	159 [e]
1000 F	172–173	—	—	121 [f]
Elongation (in 2 in.), %				
Room Temp	6.6–12.0	10	10.0	7.5
500 F	9.8–9.9	—	13.3	15.2
800 F	10.8–12.0	—	15.0	15.2 [e]
1000 F	11.8–15.0	—	—	19.8 [f]
Red. of Area, %				
Room Temp	27.0–39.9	37	38	26.8
500 F	33.0–42.1	—	35	55.0
800 F	35.2–42.2	—	52 (700 F)	55.0 [e]
1000 F	42.5–43.0	—	—	64.5 [f]
Impact Str (Charpy), ft-lb				
—200 F	10	—	11	10
Room Temp	15–22	18	22	14
500 F	31	—	23	26
Fatigue Str (10^6 cycles), 1000 psi	130–135	110	116	110
Rupture Str (900 F), 1000 psi				
10 Hr	240–242	—	—	—
100 Hr	210–212	—	—	144
1000 Hr	140–150	—	—	97
FABRICATING PROPERTIES				
Hot Working Temp Range, F	1700–2100	1650–1950	1700–2250	1800–2250
Machinability	Readily machined in annealed condition			
Weldability	Readily fusion welded with shielded arc; preheat to 1000 F, postheat at 600 F	Excellent by tungsten-arc inert-gas method	Readily welded by all conventional methods	Readily welded by conventional methods; preheat to 450–550 F, postheat at 600 F
AVAILABLE FORMS	Bar, billets, forgings, plate, sheet, strip, wire [g]			
USES	Aircraft and missile turbine housings, engine mounts, landing gear, airframes and other high strength, high temperature components	High strength, thin-wall rocket motor cases, landing gear and other high strength aircraft structural components	Aircraft landing gear and other high strength components	High strength, thin-wall rocket motor cases, landing gear and other high strength aircraft structural components

[a] Properties for materials in the following conditions:
Modified H-11: range of properties due to variations in heat treatments and type of melting procedure (air or vacuum). These alloys are commercially available in either condition and are known as Vascojet 1000, Unimach I, Potomac A, etc.
MX-2: austenitized at 1700 F, oil quenched, double tempered at 500–600 F.
300–M: normalized at 1700 F, austenitized at 1600 F, oil quenched, tempered at 600 F.
D–6A: normalized at 1650 F, oil quenched, tempered at 500–700 F.
[b] 80–1200 F. [c] 80–600 F. [d] 0–600 F. [e] Tempered at 850 F. [f] Tempered at 1050 F. [g] 300–M also available as castings.

Age Hardenable Stainless Steels—Wrought

Type ➔	Stainless W	17-4 PH	17-7 PH	PH 15-7 Mo	17-14 Cu Mo
COMPOSITION, %	C 0.12 max, Mn 1.0 max, Si 1.0 max, Ni 7.0, Cr 17.0, Ti 1.2, Al 0.50, Fe bal	C 0.07 max, Mn 1.0 max, Si 1.0 max, Cr 16.5, Ni 4.0, Cu 4.0, Cb+Ta 0.30	C 0.09 max, Mn 1.0 max, Si 1.0 max, Cr 17.0, Ni 7.1, Al 1.0, Fe bal	C 0.09 max, Mn 1.0 max, Si 1.0 max, Cr 15.0, Ni 7.0, Mo 2.5, Al 1.0, Fe bal	C 0.12, Mn 0.75, Si 0.50, Cr 15.9, Ni 14.1, Mo 2.50, Cu 3.0, Cb 0.45, Ti 0.25, Fe bal
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.280	0.281	0.276	0.277	0.287
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	12.1	10.4	9.7	9.3	8.7
Coef of Ther Exp (70-200 F), per °F	5.5×10^{-6}[c]	6.0×10^{-6}	5.6×10^{-6}	$5\text{-}6 \times 10^{-6}$	8.2×10^{-6}
Elec Res (68 F), microhm-cm	85	77	82	82	—
Magnetic Permeability (max)	101	151	145	150	—
MECHANICAL PROPERTIES[a, b]					
Mod of Elast in Tension, psi	28×10^6	28.5×10^6	29×10^6	29×10^6	28×10^6
Ten Str, 1000 psi					
Room Temp	195	195	200, 235	210, 240	86
800 F	146	157	143, 159	160, 182	73 (900 F)
1000 F	94	100	—, 93	110, 130	72
1200 F	41	59	—, —	—, —	34 (1500 F)
Yld Str (0.2% offset), 1000 psi					
Room Temp	180	180	185, 220	200, 225	42
800 F	135	138	129, 137	150, 152	27 (900 F)
1000 F	54	77	—, 76	105, 105	28
1200 F	24	42	—, —	—, —	26 (1500 F)
Elongation (in 2 in.), %					
Room Temp	3-15	13	9, 6	7, 6	45
800 F	13.5	10	6.5, 12	9.5, 8.5	35 (900 F)
1000 F	22.5	15	—, 26	21, 13	32
1200 F	40	15	—, —	—, —	29 (1500 F)
Impact Str (Charpy), ft-lb	—	19	6, 4	4, 4	26
Fatigue Str (10^8 cycles), 1000 psi	54-96	90	75[f], 106[f]	—	35[g]
Compr Yld Str, 1000 psi	180	180	200, 225	217, 243	—
Shear Str, 1000 psi	120	130	136, 150	143, 160	—
Creep Str (1000 hr, 800 F), 1000 psi					
0.1%	—	50	40, 31	—, 95	24[h]
0.2%	40[d]	—	45, 36	—, 109	—
Rupture Str (800 F), 1000 psi					
100 Hr	31[e]	140	110, 113	139, 174	43[h]
1000 Hr	—	128	90, 92	137, 171	37[h]
FABRICATING PROPERTIES					
Hot Working Temp Range, F	1700-2300	1800-2200	To 2150	—	2200
Machinability	Slightly easier than type 302	Same as type 410	Not often machined	Good	Same as types 302 and 304
Weldability	Readily welded by arc and resistance processes applicable to stainless steels				
CORROSION RESISTANCE	In general about the same corrosion and oxidation resistance as conventional stainless steels				
AVAILABLE FORMS	Bar, billets, extrusions, plate, sheet, strip, wire	Bar, billets, wire	All wrought forms	All wrought forms	All wrought forms
USES	Used where high strength-weight ratio, corrosion resistance and good strength at moderate temperatures are required. Specifically, airframe skin and structural parts			Used where high strength and corrosion resistance up to 1000 F are required. Specifically, aircraft parts	Used where good creep strength, impact strength and corrosion and oxidation resistance are needed at temperatures up to 1500 F

[a] Properties for materials in following conditions:
Stainless W: sheet solution annealed at 1850–1950 F, air cooled, aged ½ hr at 950 F, air cooled.
17–4 PH: bar solution annealed at 1900 F, oil or water quenched, aged 1 hr at 900 F, air cooled.
17–7 PH: two conditions: (1) TH 1050—sheet solution annealed at 1950 F, austenitized 90 min at 1400 F, air cooled to 50–60 F, held 30 min, aged 90 min at 1050 F; (2) RH 950—solution annealed at 1950 F, austenitized 10 min at 1750 F, air cooled, treated 8 hr at −100 F, aged 1 hr at 950 F. PH–15–7 Mo: same as 17–7 PH.
17–14 Cu Mo: solution annealed ½ hr at 2250 F, water quenched, aged 5 hr at 1350 F, water quenched.
[b] Where two sets of values are given they represent the TH 1050 and RH 950 conditions as given in the preceding note.
[c] 32–212 F. [d] 500 hr. [e] At 1000 F. [f] Vapor blasted surface. [g] 10^8 cycles at 1200 F. [h] At 1200 F.

Age Hardenable Stainless Steels—Wrought, Cast

Type ➔	AM-350	AM-355	Cast AM-355	Cast 17-4PH
COMPOSITION, %	C 0.10, Mn 0.80, Si 0.25, Cr 16.5, Ni 4.3, Mo 2.75, N 0.10, Fe bal	C 0.13, Mn 0.95, Si 0.25, Cr 15.5, Ni 4.3, Mo 2.75, N 0.10, Fe bal	C 0.10, Mn 0.80, Si 0.60, Cr 15.0, Ni 4.2, Mo 2.3, N 0.09, Fe bal	C 0.07, Mn 1.0, Si 1.0, Cr 15-17, Ni 3-5, Cu 2.3-3.0, Fe bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.282	0.282	0.282	0.280
Melting Temp, F	2500–2550	2500–2550	2500–2550	—
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	8.87	9.18	9.18	10.4
Coef of Ther Exp (68–212 F), per °F	6.3×10^{-6}	6.4×10^{-6}	6.4×10^{-6}	6.0×10^{-6}
Elec Res (80 F), microhm-cm	78.8	75.7	75.7	98
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension, psi				
80 F	29.4×10^{6}	29.3×10^{6}	29.3×10^{6}	28.5×10^{6}
600 F	25.9×10^{6}	26×10^{6}	—	—
800 F	24.3×10^{6}	24.6×10^{6}	—	—
Ten Str, 1000 psi				
Room Temp	206	216	223	170 (min)
600 F	189	210	202	—
800 F	186	198	193	158
1000 F	106	144	129	—
Yld Str (0.2% offset), 1000 psi				
Room Temp	173	181	183	140 (min)
600 F	136	152	152	—
800 F	125	139	139	138
1000 F	85	97	100	—
Elongation (in 2 in.), %				
Room Temp	13.5	19.0	13.7	6 (min)
600 F	7.0	11.5	5.0	—
800 F	9.5	11.0	8.0	—
1000 F	16.0	16.0	10.5	—
Impact Str (Charpy), ft-lb[b]				
Room Temp	14.1	17.1	—	17
212 F	24.5	18.5	—	—
Creep Str (1000 hr, 800 F), 1000 psi				
0.1 %	91	100	—	120 (700 F)
0.01%	23	27	—	80 (700 F)
Rupture Str (800 F), 1000 psi				
10 Hr	188	188	—	—
100 Hr	186	186	—	—
1000 Hr	183	180	—	89
FABRICATING PROPERTIES				
Hot Working Temp, F	1700–2100	1700–2100	1700–2100	1800–1850
Machinability	Similar to conventional stainless steels			
Weldability	Readily weldable by all methods used on chromium-nickel stainless steels			
CORROSION RESISTANCE	Superior to other hardenable stainless grades; offer good resistance to boiling 65% nitric, boiling citric, boiling glacial acetic, 10% oxalic (200 F), and boiling 10% phosphoric acids			Better than 12% chromium steels and approaches 18-8 stainless
AVAILABLE FORMS	Billets, bar, forgings, sheet, strip, foil, wire, welded tubing	Sheet, strip, plate, bar, forgings, wire and electrodes	Castings	Castings
USES	Structural parts requiring high strength-weight ratio, corrosion resistance and good strength at moderate temperatures	Structural parts requiring high strength, good corrosion resistance and ease of fabrication		Chemical equipment requiring strength and galling resistance

[a] Properties for materials in the following conditions:
AM-350: sheet solution treated at 1710 F ± 25 F, air cooled or water quenched, hardened 3 hr at − 100 F, hardened 3 hr at 850–1000 F, air cooled.
AM-355: same as AM-350; elevated temperature properties are for bar stock.
Cast AM-355: same as AM-350.
Cast 17-4PH: solution annealed 1 hr at 1900 F, air cooled, hardened 1 hr at 875 F, air cooled.
[b] Bar stock.

Iron-Base Superalloys (Cr-Ni)—Wrought

Type ➔	19-9DL	Unitemp 212	W 545	Discaloy	D-979
COMPOSITION, %	C 0.32, Mn 1.15, Si 0.55, Cr 18.5, Ni 9.0, Mo 1.40, W 1.35, Cb+Ta 0.40, Ti 0.25, Cu 0.15, Fe bal	C 0.08, Mn 0.05, Si 0.15, Cr 16.0, Ni 25.0, Ti 4.0, Al 0.15, Cb+Ta 0.50, B 0.06, Zr 0.05, Fe bal	C 0.02, Mn 1.65, Si 0.40, Cr 13.5, Ni 26.0, Mo 1.75, Ti 3.00, Al 0.15, B 0.05, Fe bal	C 0.04, Mn 0.9, Si 0.8, Cr 13.5, Ni 26.0, Ti 1.75, Mo 2.75, Al 0.07, Cu 0.05, Fe bal	C 0.05, Mn 0.50, Si 0.50, Cr 15.0, Ni 45.0, Mo 3.75, W 3.75, Ti 3.0, Al 1.0, B 0.01, Fe bal
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.287	0.286	0.285	0.288	0.295
Ther Cond (1200 F), Btu/hr/sq ft/°F/ft	12.2	13.7	10.7	13.0	—
Melting Temp, F	2560–2615	2480	2460–2530	2516–2664	2225–2550
Coef of Ther Exp (70–1500 F), per °F	10×10^{-6}	10×10^{-6}	10.7×10^{-6}	9.6×10^{-6}	9.5×10^{-6}
Specific Heat, Btu/lb/°F	0.10	—	0.115	0.113	—
Elec Res (200 F), microhm-cm	—	91[c]	92.8	99.7	—
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension, psi					
Room Temp	29.5×10^6	29.0×10^6	28.4×10^6	28.3×10^6	30.0×10^6
1000 F	23.3×10^6	23.3×10^6	23.5×10^6	22.2×10^6	26.0×10^6
1200 F	22.0×10^6	22.0×10^6	21.3×10^6	21.0×10^6	24.0×10^6
1400 F	20.7×10^6	20.5×10^6	17.5×10^6	—	22.5×10^6
Ten Str, 1000 psi					
Room Temp	114	187	181	145	204
1000 F	79	—	154	125	189
1200 F	62	144	134	104	161
1400 F	50	102	91	82 (1350 F)	105
Yld Str (0.2% offset), 1000 psi					
Room Temp	71	134	133	106	146
1000 F	55	—	121	94	134
1200 F	52	122	115	91	129
1400 F	40	97	82	74 (1350 F)	94
Elongation (in 2 in.), %					
Room Temp	41	23	19	19	16
1000 F	24	—	14	16	15
1200 F	35	18	18	19	20
1400 F	35	16	28	14 (1350 F)	17
Impact Str (Charpy), ft-lb					
Room Temp	46[e]	30–42	30	36	—
1200 F	56[e]	36–42	23	35	—
Fatigue Str (10^8 cycles), 1000 psi					
Room Temp	81[e]	—	69	55	—
1200 F	52[e]	62	56	51	—
Rupture Str (1350 F), 1000 psi					
100 Hr	44 (1200 F)	63	60 (1300 F)	30	48[d]
1000 Hr	37 (1200 F)	43	46 (1300 F)	25 (500 hr)	34[d]
FABRICATING PROPERTIES					
Hot Working Temp, F	1200–2150	1900–1950	1700–2000	1800–2150	1750–2100
Machinability Index[b]	40	—	25	25	—
Weldability	Excellent	Limited data	Limited data	Limited data	—
CORROSION RESISTANCE	Excellent res to acids, exhaust gases	Excellent up to 1400 F	Excellent up to 1300 F	Excellent up to 1300 F	Excellent up to 1600 F
AVAILABLE FORMS	Billets, bar, wire, sheet, strip, tubing, forgings	Billets, bar, wire, sheet, strip	Billets, bar, strip, plate, sheet, forgings	Billets, bar, strip, plate, sheet, wire, forgings	Billets, bar, sheet, forgings
USES	Highly stressed missile and jet engine parts at elevated temperatures				

[a] Properties for material in the following conditions:
19–9DL: hot rolled bar stress relieved 8 hr at 1350 F, air cooled.
Unitemp 212: bar solution treated 2 hr at 1850 F, air cooled, aged 16 hr at 1325 F, air cooled.
W 545: bar solution treated 3 hr at 2000 F, water quenched, aged 20 hr at 1375 F and 20 hr at 1200 F, air cooled.
Discaloy: forging solution treated 2 hr at 1650 F, water quenched, aged 10 hr at 1350 F and 40 hr at 1200 F, air cooled.
D 979: bar solution treated 1 hr at 1850 F, oil quenched, aged 4 hr at 1550 F and 16 hr at 1300 F, air cooled.
[b] Based on AISI B1112 Steel = 100. [c] At 70 F.
[d] Stress rupture values can be increased to 73,000 psi for 100 hr and 57,000 psi for 1000 hr (with a decrease in tensile properties) by solution treating at 2050 F. [e] Hot rolled bar stress relieved at 1200 F, air cooled.

Iron-Base Superalloys (Cr-Ni)—Wrought

Type →	A-286	V-57	16-25-6	Incoloy 901
COMPOSITION, %	C 0.08 max, Mn 1.35, Si 0.95, Cr 15.00, Ni 26.0, Mo. 1.25, Ti 2.15, V 0.30, Al 0.20, B 0.003, Fe bal	C 0.06, Mn 0.25, Si 0.55, Cr 15.0, Ni 25.5, Mo 1.25, Ti 3.0, Al 0.25, V 0.025, Fe bal	C 0.10 max, Mn 2.0 max, Si 1.0 max, Cr 16.25, Ni 25.5, Mo 6.0, Fe bal	C 0.05, Mn 1.50, Si 0.40, Cr 13.0, Ni 43.0, Ti 2.80, Mo 6.0, Al 0.20, B 0.015, Fe bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.286	—	0.291	0.296
Melting Temp Range, F	2500–2600	—	—	—
Ther Cond (1100 F), Btu/hr/sq ft/°F/ft	13.7	—	15.0	—
Coef of Ther Exp (80–1400 F), per °F	10.3×10^{-6}	10.5×10^{-6}	9.4×10^{-6}	9.2×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	—	—	—
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension, psi				
Room Temp	29.1×10^{6}	—	28.2×10^{6}	29.9×10^{6}
1000 F	23.5×10^{6}	—	—	24.2×10^{6}
1200 F	22.2×10^{6}	—	17.9×10^{6}	22.1×10^{6}
1500 F	19.8×10^{6}	—	10.0×10^{6}	—
Ten Str, 1000 psi				
Room Temp	150	172	142	175
1200 F	104	129	90	145
1400 F	64	100 (1350 F)	60	105
1500 F	37	60	47	80
Yld Str (0.2% offset), 1000 psi				
Room Temp	100	119	112	128
1200 F	88	108	75	115
1400 F	—	89 (1350 F)	50	88
1500 F	—	49	37	73
Elongation (in 2 in.), %				
Room Temp	25	24	23	—
1200 F	13	22	12	—
1400 F	19	23 (1350 F)	11	—
1500 F	69	40	9	—
Impact Str (Charpy), ft-lb				
Room Temp	60	—	15	—
1000 F	46	—	50 (1500 F)	—
Fatigue Str (10^8 cycles, 1200 F), 1000 psi	38	—	46	—
Creep Str (0.0001%/hr), 1000 psi				
1200 F	30	—	19	—
1350 F	16	—	13	—
Rupture Str (1350 F), 1000 psi				
100 Hr	35	40	28	50
1000 Hr	21	25	21	30
FABRICATING PROPERTIES				
Hot Working Temp, F	1700–2150	1950–2050	2100 (max)	1850–2200
Forgeability	Excellent	Excellent	—	Good
Machinability Index[b]	27	25	31	20
Weldability	Limited data	Limited data	Limited data	Limited data
CORROSION RESISTANCE	Excellent up to 1300 F in all atmospheres encountered in jet engine service		Good corrosion and oxidation resistance at elevated temperatures	Adequate oxidation resistance in range of 1000–1400 F
AVAILABLE FORMS	Billets, bar, sheet, strip, tubing, forgings, wire	Billets, bars, forgings, wire, sheet	Billets, bar, sheet, rod, forgings	Sheet, bar
USES	Jet engine turbine wheels, blades, frames, casings, afterburner parts, bolts and miscellaneous hardware		Gas turbines; jet engine wheels, buckets, rotors	Jet engine wheels and disks

[a] Properties for materials in the following conditions:
A-286: bar solution treated 1 hr at 1800 F, oil quenched, aged 16 hr at 1325 F, air cooled.
16-25-6: bar solution treated 10 min at 2150 F, water quenched, cold worked 20%, stress relieved 4 hr at 1250 F.
V-57: bar solution treated 2 hr at 1800 F, oil quenched, aged 16 hr at 1350 F, air cooled.
Incoloy 901: solution treated 2 hr, water quenched, aged 2 hr at 1450 F, air cooled, aged 24 hr at 1325 F.
[b] Based on AISI B1112 steel = 100.

Iron-Base Superalloys (Cr-Ni-Co)—Cast, Wrought

Type →	Multimet, N-155	Refractaloy 26	S-590
COMPOSITION, %	C 0.10, Mn 1.50, Si 0.70, Cr 20.75, Ni 19.85, Co 19.50, Mo 2.95, W 2.35, Cb+Ta 1.15, Cu 0.20, Fe bal	C 0.03, Mn 0.8, Si 1.0, Cr 18.0, Ni 38.0, Co 20.0, Mo 3.2, Ti 2.6, Al 0.2, Fe bal	C 0.4, Mn 1.5, Si 0.4, Cr 20.0, Ni 20.0, Co 20.0, Mo 4.0, W 4.0, Cb 4.0, Fe bal
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.296	0.296	0.301
Melting Temp, F	2350–2470	2450	2400–2500
Coef of Ther Exp (70–1000 F), per °F	9.1×10^{-6}	8.2×10^{-6}	8.0×10^{-6}
Spec Ht (70–212 F), Btu/lb/°F	0.104	0.108	0.10
MECHANICAL PROPERTIES[a]			
Mod of Elast in Tension, psi			
Room Temp	28.8×10^6	30.6×10^6	31.1×10^6
1000 F	24.6×10^6	26.3×10^6	—
1200 F	21.7×10^6	25.0×10^6	24.6×10^6
Ten Str, 1000 psi			
Room Temp	118	154	142
1000 F	94	143	132
1200 F	74	136	95
1400 F	59	71 (1500 F)	62
1600 F	39	48	—
Yld Str (0.2% offset), 1000 psi			
Room Temp	58	91	75
1000 F	40	85	80
1200 F	38	89	71
1400 F	36	66 (1500 F)	51
1600 F	30	47	—
Elongation (in 2 in.), %			
Room Temp	49	19	21
1000 F	54	18	14
1200 F	28	15	24
1400 F	12	29 (1500 F)	26
1600 F	15	49	—
Impact Str (Charpy), ft-lb			
Room Temp	65	18	12
1200 F	61[c]	25	21–23
Fatigue Str (10^8 cycles), 1000 psi			
1200 F	66[d]	54	—
1500 F	33[d]	37	33
Creep Str (1.0%, 1350 F), 1000 psi			
100 Hr	20	46	25
1000 Hr	15	37	20
Rupture Str (1350 F), 1000 psi			
100 Hr	28	51	30
1000 Hr	22[e]	42	22
FABRICATING PROPERTIES			
Hot Working Temp, F	1750–2150	1600–2200	2100–2250
Machinability Index[b]	15	20	15–20
Weldability	Good	Similar to stainless steel	—
CORROSION RESISTANCE	Good oxidation and corrosion res up to 2000 F	Excellent res to oxidizing and reducing atmospheres to 1800 F	Similar to stainless steel
AVAILABLE FORMS	Bar, sheet, plate, tubing, electrodes, forgings; also sand and investment castings	Bar, springs, strip, forgings	Plate, sheet, strip, bar forgings
USES	Gas turbine blades, vanes, nozzles and other elevated temperature parts		

[a] Properties for material in the following conditions:
Multimet, N-155: solution treated 1 hr at 2200 F, rapid air cooled.
Refractaloy 26: solution treated 1 hr at 1800–2100 F, oil quenched, aged 20–44 hr at 1350–1500 F and 4–20 hr at 1500 F, air cooled.
S-590: solution treated 1 hr at 2250 F, water quenched, aged 16 hr at 1400 F, air cooled.

[b] Based on AISI B1112 steel = 100. [c] Aged 2 hr at 1200 F. [d] Aged 50 hr at 1200 F. [e] Aged 4 hr at 1500 F.

Carbon Steels—Cast

Class[a] →	60,000	65,000	70,000	80,000	85,000	100,000
PHYSICAL PROPERTIES						
Density, lb/cu in.	0.283	0.283	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	13–16	13–16	13–16	13–16	13–16	13–16
Magnetic?	Yes	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[b]						
Mod of Elast in Tension, psi	30.1×10^{6}	30.1×10^{6}	30×10^{6}	29.9×10^{6}	29.9×10^{6}	29.7×10^{6}
Ten Str, 1000 psi	60[c]	65[d]	70[d]	80[e]	85[e]	100[f]
Yld Point, 1000 psi	30[c]	35[d]	38[d]	45[e]	50[e]	70[f]
Elong (in 2 in.), %	32[c]	30[d]	28[d]	26[e]	24[e]	20[f]
Red. of Area, %	55[c]	53[d]	50[d]	43[e]	40[e]	46[f]
Hardness (Brinell)	120[c]	130[d]	140[d]	160[e]	175[e]	200[f]
Impact Str (Izod), ft-lb						
70 F	30[c]	30[d]	30[d]	25[e]	20[e]	30[f]
−50 F	8[c]	12[d]	10[d]	12[e]	10[e]	15[f]
Endurance Limit, 1000 psi	25[c]	28[d]	31[d]	35[e]	38[e]	47[f]
THERMAL TREATMENT						
Annealing Temp, F	About 200 F above critical range					
Quenching Temp, F	About 100 F above critical range					
FABRICATING PROPERTIES						
Machinability Index[g]	55	60	65	70	70	65
Weldability	Can be welded by procedures used for welding wrought steels of similar composition					
CORROSION RESISTANCE	When brought into contact with moisture and air, carbon steels rust at rates that are not affected by carbon content. If salts are present, corrosion rate is increased. Attacked readily by acids, but resistant to alkalis at ordinary temperatures					
USES	Applications requiring low electrical resistivity, good magnetic properties, carburizing and case hardening, weldability		Applications requiring excellent weldability; medium strength with good machinability and high ductility	Applications requiring high strength with good machinability, toughness and excellent fatigue resistance		Applications requiring wear resistance and hardness

[a] Tensile strength, psi.
[b] Normally expected coupon values for steel castings having tensile strength given.
[c] Annealed.
[d] Normalized.
[e] Normalized and tempered.
[f] Quenched and tempered.
[g] High speed tool steels based on AISI B1112-steel = 100.

Low Alloy Steels—Cast

Class[b] →	70,000	80,000	90,000	100,000	110,000
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	$8.0–8.3 \times 10^{-6}$	$8.0–8.3 \times 10^{-6}$	$8.0–8.3 \times 10^{-6}$	$8.0–8.3 \times 10^{-6}$	$8.0–8.3 \times 10^{-6}$
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	15–20	15–20	15–20	15–20	15–20
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[c]					
Mod of Elast in Tension, psi	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$
Ten Str, 1000 psi	70[e]	80[e]	90[e]	100[e]	110[f]
Yld Point, 1000 psi	45	50	60	68	85
Elong (in 2 in.), %	26	24	22	20	20
Red. of Area, %	56	50	46	42	45
Hardness (Brinell)	150	170	190	209	235
Impact Str (Charpy), ft-lb					
70 F	35	30	26	22	23
–50 F	25	20	15	12	18
Endurance Limit, 1000 psi	33	38	41	45	49
THERMAL TREATMENT					
Annealing Temp, F	About 200 F above critical range				
Quenching Temp, F	About 100 F above critical range				
FABRICATING PROPERTIES					
Machinability Index[d]	65	70	70	65	60
Weldability	Can be welded by procedures used for wrought steels of similar composition				
CORROSION RESISTANCE	Similar to corrosion resistance of carbon steels				
USES	Applications requiring excellent weldability; medium strength with high toughness and good machinability; good high temperature properties		Applications requiring toughness or excellent high temperature and deep hardening properties		Applications requiring high resistance to impact; excellent low temperature properties; deep hardening; or excellent combination of strength and toughness

[a] Below 8% total alloy content.
[b] Tensile strength, psi.
[c] Normally expected coupon values for steel castings having tensile strength given.
[d] High speed tool steels based on AISI B1112 steel = 100.
[e] Normalized and tempered.
[f] Quenched and tempered.

Low Alloy Steels—Cast

Class[b] →	120,000	150,000	175,000	200,000
PHYSICAL PROPERTIES				
Density, lb/cu in	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27
Coef of Ther Exp (70-1200 F), per °F	$8.0\text{–}8.3 \times 10^{-6}$	$8.0\text{–}8.3 \times 10^{-6}$	$8.0\text{–}8.3 \times 10^{-6}$	$8.0\text{–}8.3 \times 10^{-6}$
Spec Ht, Btu/lb/°F	0.10-0.11	0.10-0.11	0.10-0.11	0.10-0.11
Elec Res (68 F), microhm-cm	15-20	15-20	15-20	15-20
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[c]				
Mod of Elast in Tension, psi	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$
Ten Str, 1000 psi	120[f]	150[f]	175[f]	200[f]
Yld Point, 1000 psi	95	125	148	170
Elong. (in 2 in.), %	16	12	8	5
Red. of Area, %	38	25	20	11
Hardness (Brinell)	245	300	340	400
Impact Str (Charpy), ft-lb				
70 F	20	14	10	—
−50 F	16	10	6	—
Endurance Limit, 1000 psi	55	65	77	85
THERMAL TREATMENT				
Annealing Temp, F	About 200 F above critical range			
Quenching Temp, F	About 100 F above critical range			
FABRICATING PROPERTIES				
Machinability Index[d]	50	30	—	—
Weldability	Can be welded by procedures used for wrought steels of similar composition			
CORROSION RESISTANCE	Generally similar to carbon steels			
USES	Applications requiring high resistance to impact, excellent low temperature properties, deep hardening; excellent combination of strength and toughness	Applications requiring deep hardening, high strength, wear resistance, fatigue resistance	Applications requiring high strength, wear resistance, high hardness, high fatigue resistance	

[a] Below 8% total alloy content.
[b] Tensile strength, psi.
[c] Normally expected coupon values for steel castings having tensile strength given.
[d] High speed tool steels based on AISI B1112 steel = 100.
[f] Quenched and tempered.

Stainless Steels—Cast

ACI Type ➔	CA-15	CA-40	CB-30	CC-50
COMPOSITION, %	C 0.15 max, Mn 1.0 max, Si 1.5 max, P 0.04 max, S 0.04 max, Cr 11.5–14.0, Ni 1.0 max, Mo 0.5[a]	C 0.20–0.40, Mn 1.0 max, Si 1.50 max, P 0.04 max, S 0.04 max, Cr 11.5–14.0, Ni 1.0 max, Mo 0.5[a]	C 0.30 max, Mn 1.0 max, Si 1.0 max, P 0.04 max, S 0.04 max, Cr 18–22, Ni 2.0 max	C 0.50 max, Mn 1.0 max, Si 1.0 max, P 0.04 max, S 0.04 max, Cr 26–30, Ni 4.0 max
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.275	0.275	0.272	0.272
Melting Point, F	2750	2725	2725	2725
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	14.5	14.5	12.8	12.6
Coef of Ther Exp (70–1000 F), per °F	6.4×10^{-6}	6.4×10^{-6}	6.5×10^{-6}	6.4×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.11	0.11	0.11	0.12
Elec Res (70 F), microhm-cm	78	76	76	77
Magnetic Permeability	Ferromagnetic	Ferromagnetic	Ferromagnetic	Ferromagnetic
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	29×10^6	29×10^6	29×10^6	29×10^6
Ten Str, 1000 psi				
Annealed	—	—	95[f]	97[g]
As Cast	—	—	—	70–95
Hard. & Temp	200[c], 100[d]	220[c], 110[e]	—	—
Yld Str (0.2% offset), 1000 psi				
Annealed	—	—	60[f]	65[g]
As Cast	—	—	—	60–65
Hard. & Temp	150[c], 75[d]	165[c], 67[e]	—	—
Elong (in 2 in.), %				
Annealed	—	—	15[f]	18[g]
As Cast	—	—	—	2–15
Hard. & Temp	7[c], 30[d]	1[c], 18[e]	—	—
Hardness (Brinell)				
Annealed	—	—	195[f]	210[g]
As Cast	—	—	—	193–212
Hard. & Temp	390[c], 185[d]	470[c], 212[e]	—	—
Impact Str (Charpy, keyhole notch), ft-lb				
As Cast	—	—	—	2–45 (Izod V notch)
Hard. & Temp	15[c], 35[d]	1[c], 3[e]	—	—
THERMAL TREATMENT				
Annealing Temp, F[b]	1450–1650 f.c.	1450–1650 f.c.	1450 f.c. and 1000 a.c.	1450 f.c. or a.c.
Hardening Temp, F[b]	1800–1850 a.c. or o.q.	1800–1850 a.c. or o.q.	Practically nonhardenable by heat treatment	Nonhardenable by heat treatment
Tempering Temp, F	<600 or 1100–1500. Highest strength and corrosion resistance by tempering below 600		—	—
FABRICATING PROPERTIES				
Castability	Sections from 3/16 in. up can be cast satisfactorily. Somewhat lighter sections can be cast in some parts. Difficult-to-run thin sections and designs involving appreciable changes in section should be avoided. Normal shrinkage for these alloys is 1/4 in. per ft, except CC–50 which shrinks 5/32 in. per ft			
Weldability	Can be welded by metal arc, inert-gas arc and oxyacetylene gas methods. Metal arc most frequently used. Oxyacetylene welding not advisable because of possible reduction in corrosion resistance resulting from carbon pickup. Castings should be preheated and postheated			
CORROSION RESISTANCE	Good atmospheric corrosion resistance. Excellent resistance to many organic media in relatively mild service		Resists nitric acid, alkaline solutions, many organic chemicals, oxidizing atmospheres up to 1400 F	Excellent resistance to dilute sulfuric acid in mine waters, mixed nitric and sulfuric acids, and oxidizing acids
USES	Pump casing, bushings and liners, impellers, shafts, turbine blades, stuffing boxes	Choppers, cutting blades, cylinder liners, pump parts, steam turbine parts, molds and dies	Furnace brackets and hangers, pump parts, rabble arms, tube supports, valve bodies	Bushings, cylinder liners, pump casings and impellers, valve bodies and seats

[a] Molybdenum not intentionally added.
[b] f.c. = furnace cool, a.c. = air cool, o.q. = oil quench.
[c] Air cooled from 1800 F, tempered at 600 F.
[d] Air cooled from 1800 F, tempered at 1450 F.
[e] Air cooled from 1800 F, tempered at 1400 F.
[f] Annealed at 1450 F, furnace cooled to 1000 F, air cooled.
[g] Air cooled from 1900 F.

Stainless Steels—Cast

ACI Type ➡	CD-4MCu	CE-30	CF-3	CF-8	CF-20
COMPOSITION, %	C 0.04 max, Mn 1.0 max, Si 1.0 max, Cr 25–27, Ni 4.75–6.0, Mo 1.75–2.25, Cu 2.75–3.25	C 0.30 max, Mn 1.50 max, Si 2.0 max, P 0.04 max, S 0.04 max, Cr 26–30, Ni 8–11	C 0.03 max, Mn 1.50 max, Si 2.0 max, Cr 17–21, Ni 8–12	C 0.08 max, Mn 1.50 max, Si 2.0 max, P 0.04 max, S 0.04 max, Cr 18–21, Ni 8–11	C 0.20 max, Mn 1.50 max, Si 2.0 max, P 0.04 max, S 0.04 max, Cr 18–21, Ni 8–11
PHYSICAL PROPERTIES					
Density, lb/cu in	0.277	0.277	0.280	0.280	0.280
Melting Point, F	2650	2550	2625	2600	2575
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	—	—	9.2	9.2	9.2
Coef of Ther Exp (70–1000 F), per °F	6.5×10^{-6}	9.6×10^{-6}	10×10^{-6}	10.0×10^{-6}	10.4×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.12	0.14	0.12	0.12	0.12
Elec Res (70 F), microhm-cm	—	85	76	76	77.9
Magnetic Permeability	Ferromagnetic	>1.5	1.0–2.0	1.0–1.3[e]	1.01
MECHANICAL PROPERTIES[b]					
Mod of Elast in Tension, psi	29×10^{6}	25×10^{6}	27×10^{6}	28×10^{6}	28×10^{6}
Ten Str, 1000 psi	105, 140[d]	97	77	77	77
Yld Str (0.2% offset), 1000 psi	85, 110[d]	63	37	37	36
Elongation (in 2 in.), %	25, 15[d]	18	55	55	50
Hardness (Brinell)	260, 300[d]	170	140	140	163
Impact Str (Charpy keyhole notch), ft-lb	37, 12[d]	—	75	74	60
FABRICATING PROPERTIES					
Castability	Sections from 3/16 in. up can be cast satisfactorily. Somewhat lighter sections are also possible in some parts. Good castability of these alloys permits designs involving intricate shapes, but drastic changes in section should be avoided and uniform thickness should be maintained as far as possible				
Weldability	Can be welded by metal arc, inert-gas arc and oxyacetylene gas methods. Metal arc most frequently used. Oxyacetylene welding not advisable because of possible reduction in corrosion resistance caused by carbon pickup. Preheating not necessary, but castings should be quenched from the range 1950 to 2100 F to restore maximum corrosion resistance. This heat treatment is not always necessary, however, with CE-30 or CF-3				
CORROSION RESISTANCE	Resists strongly oxidizing media such as boiling nitric acid, sulfuric acid and sulfates, and organic acids	Particularly resistant to sulfurous acid, mixtures of dilute sulfuric and sulfurous acids, sulfuric and nitric acids, and sulfites	Similar to CD-4MCu		Similar to CD-4MCu but used under less drastic conditions
USES	Corrosion-erosion service: pump impellers, valves, digesters, processing equipment requiring higher strength than CF-8	Process equipment such as digester fittings, fractionating towers, piping, pump bodies and casings, valve bodies and parts	Autoclaves, blast furnaces, bushings, filter press plates, hardware, headers and heating coils, pump parts, spray nozzles, valve parts; CF-3 especially useful where castings cannot be heat treated after welding		Cylinder liners, pumps, return bends, rolls, circuit breaker parts, valve parts

[b] Water quenched from 2000 F.
[d] Water quenched from 2000 F plus 3 hr at 900 F
[e] After heat treatment.

continued on next page

Stainless Steels—Cast

ACI Type →	CF-3M	CF-8M, CF-12M	CF-8C	CF-16F
COMPOSITION, %	C 0.03 max, Mn 1.5 max, Si 1.5 max, Cr 17–21, Ni 9–13, Mo 2–3	C 0.08 max (CF–8M) or 0.12 max (CF–12M), Mn 1.5 max, Si 2.0 max, P 0.04 max, S 0.04 max, Cr 18–21, Ni 9–12, Mo 2–3	C 0.08 max, Mn 1.5 max, Si 2.0 max, P 0.04 max, S 0.04 max, Cr 18–21, Ni 9–12, Cb 1.0 max[b]	C 0.16 max, Mn 1.5 max, Si 2.0 max, P 0.17 max, S 0.04 max, Cr 18–21, Ni 9–12, Se 0.2–0.35, Mo 1.5 max
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.280	0.280	0.280	0.280
Melting Point, F	2550	2550	2600	2550
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	9.4	9.4	9.3	9.4
Coef of Ther Exp (70–1000 F), per °F	9.7×10^{-6}	9.7×10^{-6}	10.3×10^{-6}	9.9×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.12	0.12	0.12	0.12
Elec Res (70 F), microhm-cm	82	82	71	72
Magnetic Permeability	1.5–2.5	1.50–2.50	1.20–1.80	1.0–2.0
MECHANICAL PROPERTIES[c]				
Mod of Elast in Tension, psi	27×10^6	28×10^6	28×10^6	28×10^6
Ten Str, 1000 psi	80	80	77	77
Yld Str (0.2% offset), 1000 psi	42	42	38	40
Elongation (in 2 in.), %	50	50	39	52
Hardness (Brinell)	156–170	156–170	149	150
Impact Str (Charpy, keyhole notch), ft-lb	70	70	30	75
FABRICATING PROPERTIES				
Castability	Sections from 3/16 in. up can be cast satisfactorily. Somewhat lighter sections are also possible in some parts. Good castability of these alloys permits designs involving intricate shapes, but drastic changes in section should be avoided and uniform thickness should be maintained as far as possible			
Weldability	Can be welded by metal arc, inert-gas arc and oxyacetylene gas methods. Metal arc most frequently used. Oxyacetylene welding not advisable because of possible reduction in corrosion resistance caused by carbon pickup. Preheating not necessary, but castings should be quenched from the range 1950 to 2100 F to restore maximum corrosion resistance. This heat treatment is not always necessary, however, with CF-3M or CF-8C			
CORROSION RESISTANCE	Resists reducing media. More resistant to pitting corrosion than CF–8 in contact with chlorides. Not as resistant to boiling nitric acid as CF–8		Resists strongly oxidizing media such as boiling nitric acid, sulfuric acid and sulfates, and organic acids	Similar to CF–8C but somewhat inferior
USES	Agitators, evaporator parts, jet engine components, spray nozzles, high pressure steam valves; especially useful where castings cannot be heat treated after welding	Agitators, evaporator parts, jet engine components, spray nozzles, high pressure steam valves	Aircraft shroud assemblies, autoclaves, chemical tubing, fittings, jet engine parts, marine fittings	Bearings, bushings, fittings, pump and machinery parts

[b] Minimum is eight times carbon content. Cb + Ta: 1.35% max; minimum is ten times carbon content.
[c] Water quenched from 2000 F.

Stainless Steels—Cast

ACI Type →	CG-8M	CH-20	CK-20	CN-7M
COMPOSITION, %	C 0.08 max, Mn 1.5 max, Si 1.5 max, Cr 18–21, Ni 9–13, Mo 3–4	C 0.20 max, Mn 1.5 max, Si 2.0 max, P 0.04 max, S 0.04 max, Cr 22–26, Ni 12–15	C 0.20 max, Mn 1.5 max, Si 2.0 max, P 0.04 max, S 0.04 max, Cr 23–27, Ni 19–22	C 0.07 max, Mn 1.5 max, Si 1.5 max, P 0.04 max, S 0.04 max, Cr 19–22, Ni 27.5–30.5, Mo 1.75–2.50, Cu 3.0 min
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.281	0.279	0.280	0.289
Melting Point, F	2550	2600	2600	2650
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	9.4	8.2	8.2	12.1
Coef of Ther Exp (70–1000 F), per °F	9.7×10^{-6}	9.6×10^{-6}	9.2×10^{-6}	9.7×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.12	0.12	0.12	0.11
Elec Res (70 F), microhm-cm	82	84	90	89.6
Magnetic Permeability	1.5–2.5	1.71[c]	1.02	1.01–1.10
MECHANICAL PROPERTIES[b]				
Mod of Elast in Tension, psi	28×10^{6}	28×10^{6}	29×10^{6}	24×10^{6}
Ten Str, 1000 psi	82	88	76	69
Yld Str (0.2% offset), 1000 psi	43	50	38	31
Elong (in 2 in.), %	50	38	37	48
Hardness (Brinell)	170	190	144	130
Impact Str (Charpy, keyhole notch), ft-lb	70	30	50 (Izod V notch)	70
FABRICATING PROPERTIES				
Castability	Sections from 3/16 in. up can be cast satisfactorily. Somewhat lighter sections are also possible on some parts. Good castability permits designs involving intricate shapes, but drastic changes in section should be avoided and uniform thickness should be maintained as far as possible			
Weldability	Can be welded by metal arc, inert-gas arc, and oxyacetylene gas methods. Metal arc welding most used. Oxyacetylene welding not advisable because of possible reduction in corrosion resistance resulting from carbon pickup			
	Preheating not necessary, but castings should be quenched from 2000–2100 F to restore maximum corrosion resistance			Preheating at 400 F necessary. After welding, castings should be quenched from 2000 F
CORROSION RESISTANCE	Similar to CF-8M, but preferred in reducing environments	Resistant to hot dilute sulfuric acid. Superior to CF-8 in certain media	Similar to CH-20, but better resistance at elevated temperatures	Resists sulfuric acid and many reducing chemicals. Good resistance to dilute hydrochloric acid and salt solutions
USES	Especially useful for applications in the pulp and paper industry	Digester fittings, roasting equipment, valves, pump parts	Digesters, filter press parts, fittings, jet engine parts, pumps, valves	Filter parts, heat exchanger parts, pickling rolls, hooks, racks and tanks; valve parts

[b] Water quenched from 2000 F.
[c] After heat treatment.

Heat Resistant Alloys—Cast

ACI Type ➡	HA	HC	HD	HE	HF
COMPOSITION, %	C 0.20 max, Mn 0.35-0.65, Si 1.00 max, P 0.04 max, S 0.04 max, Mo 0.90-1.20, Cr 8-10	C 0.50 max, Mn 1.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 26-30, Ni 4 max	C 0.50 max, Mn 1.50 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 26-30, Ni 4-7	C 0.20-0.50, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 26-30, Ni 8-11	C 0.20-0.40, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 19-23, Ni 9-12
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.279	0.272	0.274	0.277	0.280
Melting Point, F	2750	2725	2700	2650	2550
Ther Cond (212 F), Btu/hr/sq ft/ft/°F	15.2	12.6	12.6	10.0[f]	9.0
Coef of Ther Exp (70-1200 F), per °F	7.5×10^{-6}	6.4×10^{-6}	8.0×10^{-6}	9.9×10^{-6}	10.1×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.11	0.12	0.12	0.14	0.12
Elec Res (70 F), microhm-cm	70	77	81	85	80
Magnetic Permeability	Ferromagnetic	Ferromagnetic	Ferromagnetic	1.3-2.5	1.0
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	29×10^6	29×10^6	27×10^6	25×10^6	28×10^6
Ten Str, 1000 psi[b]	95^c, 107^d	70-110, 115^e	85, —	95, 90^e	85, 100^e
Yld Str (0.2% offset), 1000 psi[b]	65^c, 81^d	65-75, 80^e	48, —	45, 55^e	45, 50^e
Elong (2 in.), %[b]	23^c, 21^d	2-19, 18^e	16, —	20, 10^e	35, 25^e
Hardness (Brinell)[b]	180^c, 220^d	190-223, —	190, —	200, 270^e	165, 190^e
ELEVATED TEMPERATURE PROPERTIES					
Ten Str, 1000 psi	67 (1000 F), 44 (1100 F)	—	36 (1400 F), 23 (1600 F), 15 (1800 F)	—	57 (1200 F), 35 (1400 F), 22 (1600 F)
Yld Str (0.2% offset), 1000 psi	42 (1000 F), 32 (1100 F)	—	—	—	21 (1400 F)
Elong (2 in.), %	36 (1100 F)	—	14 (1400 F), 18 (1600 F), 40 (1800 F)	—	16 (1200 F), 20 (1400 F), 22 (1600 F)
Creep Str (0.0001%/hr), 1000 psi	16 (1000 F), 7.2 (1100 F), 3.1 (1200 F)	1.3 (1400 F), 0.75 (1600 F), 0.36 (1800 F)	3.5 (1400 F), 1.9 (1600 F), 0.9 (1800 F)	4.0 (1400 F), 2.4 (1600 F), 1.4 (1800 F)	13 (1200 F), 6.0 (1400 F), 3.2 (1600 F)
Rupture Str, 1000 psi 10 Hr	45 (1000 F)	4.6 (1400 F), 2.0 (1600 F), 1.1 (1800 F)	14 (1400 F)	—	37 (1200 F), 20 (1400 F), 10 (1600 F)
100 Hr	37 (1000 F)	3.3 (1400 F), 1.7 (1600 F), 0.85 (1800 F)	10 (1400 F), 5 (1600 F), 2.5 (1800 F)	11 (1400 F), 5.3 (1600 F), 2.5 (1800 F)	30 (1200 F), 14 (1400 F), 6.0 (1600 F)
1000 Hr	27 (1000 F)	2.3 (1400 F), 1.3 (1600 F), 0.62 (1800 F)	7 (1400 F)	—	17 (1200 F), 8.0 (1400 F), 3.8 (1600 F)
FABRICATING PROPERTIES					
Annealing Temp, F	1625	—	—	—	1900[g]
Machinability	Fair	Good	Good	Good	Good
Weldability	Weldable by all common methods. Preheating, postheating desirable		Weldable by all common methods. Preheating not required		
USES	Fan blades, furnace rollers, lehr rolls, refinery fittings, trunnions	Grate bars, dampers, kiln parts, rabble blades, salt pots, tuyeres	Brazing furnace parts, cracking equipment, furnace blowers, pouring spouts, salt pots, gas burner parts	Billet skids, burner nozzles, furnace conveyors, tube supports, soot blower elements	Electrode arms, burner tips, annealing boxes, wear plates, gas burner rings, conveyor belts, dampers

[a] Molybdenum not intentionally added. [b] As cast and heat treated values given in that order.
[c] Annealed. [d] Normalized at 1825 F, tempered at 1250 F.
[e] Aged 24 hr at 1400 F, furnace cooled. [f] At 1500 F.
[g] Before cyclic temperature service; 6 hr at 1900 F may improve life.

Heat Resistant Alloys—Cast

ACI Type →	HH		HI	HK	HL
COMPOSITION, %	C 0.20-0.50, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 24-28, Ni 11-14, N 0.2 max		C 0.20-0.50, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 26-30, Ni 14-18	C 0.20-0.60, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 24-28, Ni 18-22	C 0.20-0.60, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 28-32, Ni 18-22
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.279		0.279	0.280	0.279
Melting Point, F	2500		2550	2550	2600
Ther Cond (212F), Btu/hr/sq ft/ft/°F	8.2		10.9	8.2	8.2
Coef of Ther Exp (70-1800 F), per °F	10.5×10^{-6}		10.5×10^{-6}	10.0×10^{-6}	9.9×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.12		0.12	0.12	0.12
Elec Res (70 F), microhm-cm	75-85		—	90	94
Magnetic Permeability	1.0-1.9		1.0-1.7	1.02	1.01
	Type I[c]	Type II[e]			
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	27×10^6	27×10^6	27×10^6	29×10^6	29×10^6
Ten Str, 1000 psi[b]	80, 86	85, 92	80, 90	75, 85	82, —
Yld Str, 1000 psi[b]	50, 55	40, 45	45, 65	50, 50	52, —
Elong (2 in.), %[b]	25, 11	15, 8	12, 6	17, 10	19, —
Hardness (Brinell)[b]	185, 200	180, 200	180, 200	170, 190	192, —
ELEVATED TEMPERATURE PROPERTIES					
Ten Str, 1000 psi					
1400 F	33	35	38	—	50
1600 F	18.5	22	26	23	30
1800 F	9.0	11	—	—	18.7
Yld Str (0.2% offset), 1000 psi					
1400 F	17	18	—	—	—
1600 F	13.5	14	—	—	—
1800 F	6.3	7.0	—	—	—
Elong (2 in.), %					
1400 F	18	12	6	—	—
1600 F	30	16	12	21	—
1800 F	45	30	—	—	—
Creep Str (0.0001%/hr), 1000 psi					
1400 F	3.0	7.0	6.6	6.8	7.0
1600 F	1.7	4.0	3.6	4.2	4.3
2000 F	0.3	0.8	0.8	1.0	—
2150 F	—	—	0.15	0.2	—
Rupture Str, 1000 psi					
10 Hr 1400 F	—	20	—	23	—
10 Hr 1600 F	—	10	—	11	—
10 Hr 1800 F	4.7	6.0	—	6.5	—
100 Hr 1400 F	14	14	13	14.5	15
100 Hr 1600 F	6.4	7.5	7.5	7.8	9.2
100 Hr 2000 F	1.5	1.8	1.9	2.5	—
1000 Hr 1400 F	6.5	10	8.5	9.0	—
1000 Hr 1600 F	3.8	4.7	4.8	5.0	—
1000 Hr 2000 F	—	1.2	1.2	—	—
FABRICATING PROPERTIES					
Annealing Temp, F	1900[d]	1900[d]	—	—	—
Machinability	Fair	Fair	Fair	Good	Good
Weldability	Weldable by all common methods; no preheat or postheat required				
USES	Annealing trays, tube supports, carburizing boxes, exhaust manifolds, radiant tubes, retorts, stoker parts		Billet skids, brazing fixtures, furnace rails, lead pots, tube spacers, retorts	Heat treating fixtures, rabble arms, retorts, brazing fixtures, skid rails	Carrier fingers, enameling furnace fixtures, furnace skids, stack dampers

[a] Molybdenum not intentionally added.
[b] As cast and heat treated (aged 24 hr at 1400 F, furnace cooled), values given in that order.
[c] Partially ferritic.
[d] Before cyclic temperature service; 12 hr at 1900 F may improve life. [e] Austenitic.

continued on next page

Heat Resistant Alloys—Cast

ACI Type ➜	HN	HT	HU	HW	HX
COMPOSITION, %	C 0.20-0.50, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 19-23, Ni 23-27	C 0.35-0.75, Mn 2.00 max, Si 2.50 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 13-17, Ni 33-37	C 0.35-0.75, Mn 2.00 max, Si 2.50 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 17-21, Ni 37-41	C 0.35-0.75, Mn 2.00 max, Si 2.50 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 10-14, Ni 58-62	C 0.35-0.75, Mn 2.00 max, Si 2.50 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 15-19, Ni 64-68
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.286	0.290	0.294	0.294
Melting Point, F	2500	2450	2450	2350	2350
Ther Cond (212F), Btu/hr/sq ft/ft/°F	—	7.7	—	7.7	—
Coef of Ther Exp (70-1800 F), per °F	—	9.8×10^{-6}	9.6×10^{-6}	8.8×10^{-6}	9.2×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.11	0.11	0.11	0.11	0.11
Elec Res (70 F), microhm-cm	—	100	105	112	—
Magnetic Permeability	1.10	1.10-2.00	1.10-2.00	16.0	2.0
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	27×10^6	27×10^6	27×10^6	25×10^6	25×10^6
Ten Str, 1000 psi[b]	68, —	70, 75[c]	70, 73[e]	68, 84[f]	65, 73[e]
Yld Str, 1000 psi[b]	38, —	40, 45[c]	40, 43[e]	36, 52[f]	36, 44[e]
Elong (2 in.), %[b]	17, —	10, 5[c]	9, 5[e]	4, 4[f]	9, 9[e]
Hardness (Brinell)[b]	160, —	180, 200[c]	170, 190[e]	185, 205[f]	176, 185[e]
ELEVATED TEMPERATURE PROPERTIES					
Ten Str, 1000 psi					
1400 F	—	35	40	32	—
1600 F	—	18.8	19.6	19	20.5
1800 F	—	11	10.0	10	10.7
Yld Str (0.2% offset), 1000 psi					
1400 F	—	26	—	23	—
1600 F	—	15	—	15	17.5
1800 F	—	8.0	6.2	8.0	6.9
Elong (2 in.), %					
1400 F	—	10	—	—	—
1600 F	—	26	20	—	48
1800 F	—	28	28	40	40
Creep Str (0.0001%/hr), 1000 psi					
1400 F	—	8.0	8.5	6.0	6.4
1600 F	6.3	4.5	5.0	3.0	3.2
2000 F	0.9	0.5	0.6	—	0.6
2150 F	—	0.15	—	—	—
Rupture Str, 1000 psi					
10 Hr 1400 F	—	—	—	16	18
10 Hr 1600 F	—	11	—	8.2	10
10 Hr 2000 F	—	—	—	—	2.5
100 Hr 1400 F	—	18	15	10	13
100 Hr 1600 F	9.5	8.5	8.0	6.0	6.7
100 Hr 2000 F	2.5	2.5	—	—	1.7
1000 Hr 1400 F	—	12.5	—	7.8	—
1000 Hr 1600 F	6.5	7.0	6.0	4.5	4.0
1000 Hr 2000 F	0.9	1.8	—	—	0.9
FABRICATING PROPERTIES					
Annealing Temp, F		1900[d]	1900[d]	—	
Machinability	Good	Good	Good	Good	Good
Weldability	Weldable by all common methods; no preheat or postheat required				
USES	Brazing fixtures, chain, nozzles, furnace parts, radiant tubes, tube supports	Air ducts, carburizing boxes, cyanide pots, glass molds, lead pots	Articulated trays, burner tubes, lead pots, cyanide pots, muffles	Cyanide pots, gas retorts, electric heating elements, hearth plates	Autoclaves, calciner tubes, furnace parts, salt bath electrodes, muffles

[a] Molybdenum not intentionally added. [b] As cast and heat treated values given in that order.
[c] Aged 24 hr at 1400 F, air cooled. [d] Before cyclic temperature service; 6 hr at 1900 F may improve life.
[e] Aged 24 hr at 1800 F, air cooled. [f] Aged 48 hr at 1800 F, furnace cooled.

Standard Tool Steels—Wrought

AISI Type →	Water Hardening Tool Steels (W)					Shock Resisting Tool Steels (S)			
	W1, W2	W3	W4	W5	W6, W7	S1	S2	S3	S4, S5
COMPOSITION, %	C 0.60-1.40, V 0.25 (W2)	C 1.00, V 0.50	C 0.60-1.40, Cr 0.25	C 1.10, Cr 0.50	C 1.00, Cr 0.25-0.50, V 0.20-0.25	C 0.50, Cr 1.50, W 2.50	C 0.50, Si 1.00, Mo 0.50	C 0.50, Cr 0.75, W 1.00	C 0.55 Si, 2.00, Mn 0.80, Mo 0.40 (S5)
HEAT TREATMENTS									
Forging Temp, F	1800–1950	1800–1950	1800–1950	1800–1950	1800–1950	1850–2050	1850–2050	1850–2050	1850–2050
Anneal Temp, F	1360–1450	1360–1450	1360–1450	1360–1450	1360–1450	1450–1500	1400–1450	1450–1500	1400–1450
Hard. Temp, F	1400–1550	1400–1550	1400–1550	1400–1550	1400–1550	1650–1800	1550–1650	1500–1600	1600–1750
Quench Medium[a]	B or W	B or W	B or W	B or W	B or W	O	B or W	B or W	O or W
Temper Temp, F	300–650	300–650	300–650	300–650	300–650	400–1200	300–800	300–600	350–800
Hardness, Rockwell	C65–50	C65–50	C65–50	C65–50	C65–50	C58–40	C60–50	C59–50	C60–50
SERVICE PROPERTIES[b]									
Depth of Hard	Shallow	Shallow	Shallow	Shallow	Shallow	Medium	Medium	Medium	Medium
Nondeformability	Poor	Poor	Poor	Poor	Poor	Fair	Poor	Poor	Poor-fair
Safety in Hard	Fair	Fair	Fair	Fair	Fair	Good	Poor	Poor	Poor-good
Toughness	Good	Good	Good	Good	Good	Very good	Best	Good	Best
Wear Res	Fair-good	Fair-good	Fair-good	Fair-good	Fair-good	Fair	Fair	Fair	Fair
Machinability	Best	Best	Best	Best	Best	Fair	Fair	Fair	Fair
Res to Decarb	Best	Best	Best	Best	Best	Fair-good	Poor	Fair	Poor
REMARKS	Shallow hardening, hard case, tough core; subject to distortion during heat treatment; do not retain properties above about 350 F					Better toughness, less wear resistance than W grades; can be carburized for greater hardness and wear resistance; subject to distortion during heat treatment			
TYPICAL USES	All types of tools and dies for short runs, especially cold heading dies					Punching, shearing or trimming dies			

[a] B = brine; W = water; O = oil.
[b] Values on this and next four pages are relative to all tool steels covered.

continued on next page

Standard Tool Steels—Wrought

AISI Type ➡	Cold Work Tool Steels—Oil Hardening (O)			Cold Work Tool Steels—Air Hardening (A)			
	O1	O2	O7	A2	A4	A5	A6
COMPOSITION, %	C 0.90, Mn 1.00, Cr 0.50, W 0.50	C 0.90, Mn 1.00	C 1.20, Cr 0.75, W 1.75	C 1.00, Cr 5.00, Mo 1.00	C 1.00, Mn 2.00, Cr 1.00, Mo 1.00	C 1.00, Mn 3.00, Cr 1.00, Mo 1.00	C 0.70, Mn 2.00, Cr 1.00, Mo 1.00
HEAT TREATMENTS							
Forging Temp, F	1800–1950	1800–1925	1800–2000	1850–2000	1850–2000	1850–2000	1400–2050
Anneal Temp, F	1400–1450	1375–1425	1450–1500	1550–1600	1360–1400	1360–1400	1350–1375
Hard Temp, F	1450–1500	1400–1475	1450–1625	1700–1800	1500–1600	1450–1550	1525–1600
Quench Medium[a]	O	O	O or W	A	A	A	A
Temper Temp, F	300–500	300–500	325–550	350–1000	300–800	300–800	300–800
Hardness, Rockwell	C62–57	C62–57	C64–58	C62–57	C62–54	C60–54	C60–54
SERVICE PROPERTIES							
Depth of Hard	Medium	Medium	Medium	Deep	Deep	Deep	Deep
Nondeformability	Very good	Very good	O: Very good W: Poor	Best	Best	Best	Best
Safety in Hard	Very good	Very good	O: Very good W: Poor	Best	Best	Best	Best
Toughness	Fair	Fair	Fair	Fair	Fair	Fair	Fair
Wear Res	Good	Good	Good	Very good	Good	Good	Good
Machinability	Good	Good	Good	Fair	Fair-poor	Fair-poor	Fair-poor
Res to Decarb	Good	Good	Good	Fair	Good-fair	Good-fair	Good-fair
REMARKS AND USES	Better hardenability and less distortion than W types; dies of all types			Less distortion, better safety in hardening than O types; dies of all types			

AISI Type ➡	Cold Work Tool Steels—High Carbon-High Chromium (D)						
	D1	D2	D3	D4	D5	D6	D7
COMPOSITION, %	C 1.00, Cr 12.00, Mo 1.00	C 1.50, Cr 12.00, Mo 1.00	C 2.25, Cr 12.00	C 2.25, Cr 12.00, Mo 1.00	C 1.50, Cr 12.00, Mo 1.00, Co 3.00	C 2.25, Si 1.00, Cr 12.00, W 1.00	C 2.35, Cr 12.00, Mo 1.00, V 4.00
HEAT TREATMENTS							
Forging Temp, F	1850–2000	1850–2000	1850–2000	1850–2000	1850–2000	1850–2000	2050–2125
Anneal Temp, F	1600–1650	1600–1650	1600–1650	1600–1650	1600–1650	1600–1650	1600–1650
Hard. Temp, F	1775–1850	1800–1875	1700–1800	1775–1850	1800–1875	1700–1750	1850–1950
Quench Medium[a]	A	A	O	A	A	O	A
Temper Temp, F	400–1000	400–1000	400–1000	400–1000	400–1000	400–1000	300–1000
Hardness, Rockwell	C61–54	C61–54	C61–54	C61–54	C61–54	C61–54	C65–58
SERVICE PROPERTIES							
Depth of Hard	Deep	Deep	Deep	Deep	Deep	Deep	Deep
Nondeformability	Best	Best	Very good	Best	Best	Very good	Best
Safety in Hard	Best	Best	Good	Best	Best	Good	Best
Toughness	Fair	Poor	Poor	Poor	Poor	Poor	Poor
Wear Res	Very good	Best	Best	Best	Best	Best	Best
Machinability	Poor	Poor	Poor	Poor	Poor	Poor	Poor
Res to Decarb	Fair	Fair	Fair	Fair	Fair	Fair	Fair
REMARKS AND USES	Very wear resistant, difficult to machine; little distortion during heat treatment; long runs in all types of tools and dies						

[a] A = air; O = oil; W = water.

Standard Tool Steels—Wrought

AISI Type →	Hot Work Tool Steels (H)						
	Chromium-Base						Tungsten-Base
	H11	H12	H13	H14	H15	H16	H20, H21
COMPOSITION, %	C 0.35, Cr 5.00, Mo 1.50, V 0.40	C 0.35, Cr 5.00, Mo 1.50, W 1.50, V 0.40	C 0.35, Cr 5.00, Mo 1.50, V 1.00	C 0.40, Cr 5.00, W 5.00	C 0.40, Cr 5.00, Mo 5.00	C 0.55, Cr 7.00, W 7.00	C 0.35, Cr 2.00–3.50, W 9.00
HEAT TREATMENTS							
Forging Temp, F	1950–2100	1950–2100	1950–2100	1950–2100	1900–2100	1950–2150	1950–2150
Anneal Temp, F	1550–1650	1550–1650	1550–1650	1600–1650	1550–1600	1600–1650	1600–1650
Hard. Temp, F	1825–1875	1825–1875	1825–1900	1850–1950	2100–2300	2050–2150	2000–2200
Quench Medium[a]	A	A	A	A	A or O	A or O	A or O
Temper Temp, F	1000–1200	1000–1200	1000–1200	1100–1200	1100–1200	1050–1250	1100–1250
Hardness, Rockwell	C54–38	C55–38	C53–38	C47–40	C49–36	C60–45	C54–36
SERVICE PROPERTIES							
Depth of Hard	Deep	Deep	Deep	Deep	Deep	Deep	Deep
Nondeformability	Very good	Very good	Very good	Good	A: Good O: Fair	Good	A: Good O: Fair
Safety in Hard	Best	Best	Best	Best	Fair	Good	Good
Toughness	Good	Good	Good	Good	Good	Good	Good
Wear Res	Fair	Fair	Fair	Fair	Fair	Fair	Fair-good
Machinability	Fair	Fair	Fair	Fair	Fair	Fair	Fair
Res to Decarb	Fair	Fair	Fair	Fair	Poor	Fair	Fair
REMARKS AND USES	Little distortion in heat treatment; dies for die casting, forging, extrusion, punching, etc. for use at temp up to 900 F						Some distortion; dies up to 1100 F

AISI Type →	Hot Work Tool Steels (cont'd)							
	Tungsten-Base (cont'd)					Molybdenum-Base		
	H22	H23	H24	H25	H26	H41	H42	H43
COMPOSITION, %	C 0.35, Cr 2.00, W 11.00	C 0.30, Cr 12.00, W 12.00	C 0.45, Cr 3.00, W 15.00	C 0.25, Cr 4.00, W 15.00	C 0.50, Cr 4.00, W 18.00, V 1.00	C 0.65, Cr 4.00, Mo 8.00, W 1.50, V 1.00	C 0.60, Cr 4.00, Mo 5.00, W 6.00, V 2.00	C 0.55, Cr 4.00, Mo 8.00, V 2.00
HEAT TREATMENTS								
Forging Temp, F	1950–2150	1950–2150	1950–2150	1950–2150	1950–2150	1900–2050	1900–2050	1900–2050
Anneal Temp, F	1600–1650	1600–1650	1600–1650	1600–1650	1600–1650	1500–1600	1550–1650	1500–1600
Hard. Temp, F	2000–2200	2200–2325	2000–2250	2100–2300	2150–2300	2000–2175	2050–2225	2000–2175
Quench Medium[a]	A or O	A or O	A or O	A or O	S, O or A	O, A or S	O, A or S	O, A or S
Temper Temp, F	1100–1250	1200–1500	1050–1200	1050–1250	1050–1250	1050–1200	1050–1200	1050–1200
Hardness, Rockwell	C52–39	C47–30	C55–45	C44–35	C58–43	C60–50	C60–50	C58–45
SERVICE PROPERTIES								
Depth of Hard	Deep	Deep	Deep	Deep	Deep	Deep	Deep	Deep
Nondeformability	A: Good O: Fair	A: Good O: Fair	A: Good O: Fair	A: Good O: Fair	S, A: Good O: Fair	S, A: Good O: Fair	S, A: Good O: Fair	S, A: Good O: Fair
Safety in Hard	Good	Good	Good	Good	Good	Fair	Fair	Fair
Toughness	Good	Fair	Fair	Good	Fair	Poor	Poor	Poor
Wear Res	Fair-good	Fair-good	Good	Fair	Good	Good	Good	Good
Machinability	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair
Res to Decarb	Fair	Fair	Fair	Fair	Fair	Poor	Fair	Poor
REMARKS AND USES	Tendency to distort during heat treatment; more resistant to heat than chromium-base but more susceptible to thermal shock; dies for die casting, forging, extrusion, punching, etc. at temp up to 1100 F. H24, H25 and H26 may be used at temp above 1100 F							

[a] A = air; O = oil; S = salt.

continued on next page

Standard Tool Steels—Wrought

AISI Type ➜	High Speed Tool Steels—Tungsten-Base (T)							
	T1, T2, T3	T4	T5	T6	T7	T8	T9	T15
COMPOSITION, %	C 0.70–1.05, Cr 4.00, V 1.00–3.00, W 18.00	C 0.75, Cr 4.00, W 18.00, V 1.00, Co 5.00	C 0.80, Cr 4.00, W 18.00, V 2.00, Co 8.00	C 0.80, Cr 4.50, W 20.00, V 1.50, Co 12.00	C 0.75, Cr 4.00, W 14.00, V 2.00	C 0.75, Cr 4.00, W 14.00, V 2.00, Co 5.00	C 1.20, Cr 4.00, W 18.00, V 4.00	C 1.50, Cr 4.00, W 12.00, V 5.00, Co 5.00
HEAT TREATMENTS								
Forging Temp, F	1950–2150	1950–2150	1950–2150	1950–2150	1950–2150	1950–2150	1950–2150	1950–2150
Anneal Temp, F	1600–1650	1600–1650	1600–1650	1600–1650	1600–1650	1600–1650	1600–1650	1600–1650
Hard. Temp, F	2250–2375	2300–2375	2325–2400	2325–2400	2300–2350	2300–2375	2275–2325	2200–2300
Quench Medium[a]	O, A or S	O, A or S	O, A or S	O, A or S	O, A or S	O, A or S	O, A or S	O, A or S
Temper Temp, F	1000–1100	1000–1100	1000–1100	1000–1100	1000–1100	1000–1100	1000–1100	1000–1200
Hardness, Rockwell	C66–60	C66–62	C65–60	C65–60	C65–60	C65–60	C66–61	C68–63
SERVICE PROPERTIES								
Depth of Hard	Deep	Deep	Deep	Deep	Deep	Deep	Deep	Deep
Nondeformability	Good	Good	Good	Good	Good	Good	Good	Good
Safety in Hard	Good	Fair	Fair	Fair	Good	Fair	Fair	Fair
Toughness	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
Wear Res	Very good	Very good	Very good	Very good	Very good	Very good	Best	Best
Machinability	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair
Res to Decarb	Good	Fair	Poor	Poor	Good	Fair	Good	Fair
REMARKS AND USES	Difficult to machine and grind; generally used as cutting tools							

AISI Type ➜	High Speed Tool Steels—Molybdenum-Base (M)								
	M1	M2	M3, M4	M6	M7	M8	M10	M15	M30, M34, M35, M36
COMPOSITION, %	C 0.80, Cr 4.00, Mo 8.00, W 1.50, V 1.00	C 0.80, Cr 4.00, Mo 5.00, W 6.00, V 2.00	C 1.00–1.30, Cr 4.00, Mo 4.50–5.00, W 5.50–6.00, V 2.70–4.00	C 0.80, Cr 4.00, Mo 5.00, W 4.00, V 1.50, Co 12.00	C 1.00, Cr 4.00, Mo 8.75, W 1.75, V 2.00	C 0.80, Cr 4.00, Mo 5.00, W 5.00, V 1.50, Cb 1.25	C 0.85, Cr 4.00, Mo 8.00, V 2.00	C 1.50, Cr 4.00, Mo 3.50, W 6.50, V 5.00, Co 5.00	C 0.80–0.90, Cr 4.00, V 1.25–2.00, W 2.00–6.00, Mo 5.00–8.00, Co 5.00–8.00
HEAT TREATMENTS									
Forging Temp, F	1900–2100	1900–2100	1900–2100	1900–2100	1900–2100	1900–2100	1900–2100	1900–2100	1900–2100
Anneal Temp, F	1500–1600	1600–1650	1600–1650	1600	1500–1600	1550–1600	1500–1600	1600–1650	1600–1650
Hard. Temp, F	2150–2225	2175–2250	2200–2250	2150–2200	2150–2240	2200–2300	2150–2225	2175–2250	2200–2275
Quench Medium[a]	O, A or S	O, A or S	O, A or S	O, A or S	O, A or S	O, A or S	O, A or S	O, A or S	O, A or S
Temper Temp, F	1000–1100	1000–1100	1000–1100	1000–1100	1000–1100	1000–1100	1000–1100	1000–1200	1000–1100
Hardness, Rockwell	C65–60	C65–60	C66–61	C66–61	C66–61	C65–60	C65–60	C68–63	C65–60
SERVICE PROPERTIES									
Depth of Hard	Deep	Deep	Deep	Deep	Deep	Deep	Deep	Deep	Deep
Nondeformability	Good	Good	Good	Good	Good	Good	Good	Good	Good
Safety in Hard	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair
Toughness	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
Wear Res	Very good	Very good	Very good-best	Very good	Very good	Very good	Very good	Best	Very good
Machinability	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair
Res to Decarb	Poor	Fair	Fair	Poor	Poor	Fair	Poor	Fair	Poor
REMARKS AND USES	Tend to decarburize more readily than tungsten-base tool steels; most common high speed cutting tool materials								

[a] O = oil; A = air; S = salt.

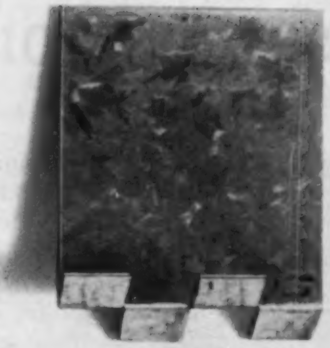
Standard Tool Steels—Wrought

AISI Type →	Special Purpose Tool Steels—Low Alloy (L)					Special Purpose—Carbon-Tungsten (F)		
	L1, L2	L3, L4	L5	L6	L7	F1	F2	F3
COMPOSITION, %	C 0.50–1.10, Cr 1.00–1.25, V 0.20 (L2)	C 1.00, Mn 0.60 (L4), Cr 1.50, V 0.20–0.25	C 1.00, Mn 1.00, Cr 1.00, Mo 0.25	C 0.70, Cr 0.75, Ni 1.50, Mo 0.25	C 1.00, Mn 0.35, Cr 1.40, Mo 0.40	C 1.00, W 1.25	C 1.25, W 3.50	C 1.25, Cr 0.75, W 3.50
HEAT TREATMENTS								
Forging Temp, F	1800–2000	1800–2000	1800–2000	1800–2000	1800–2000	1800–2000	1800–2000	1800–2000
Anneal Temp, F	1400–1475	1425–1500	1425–1475	1400–1450	1450–1500	1400–1475	1450–1500	1450–1500
Hard. Temp, F	1450–1700	1425–1600	1450–1600	1450–1550	1500–1600	1450–1600	1450–1600	1450–1600
Quench Medium[a]	O or W	O or W	O	O	O	W or B	W or B	W, B or O
Temper Temp, F	300–1000	300–600	300–600	300–1000	300–600	300–500	300–500	300–500
Hardness, Rockwell	C64–45	C64–56	C64–56	C62–45	C64–56	C64–60	C66–62	C66–62
SERVICE PROPERTIES								
Depth of Hard	Medium	Medium	Medium	Medium	Medium	Shallow	Shallow	Shallow
Nondeformability	Fair-poor	Fair-poor	Good	Good	Good	Poor	Poor	Poor
Safety in Hard	Fair-poor	Good-poor	Good	Good	Good	Poor	Poor	Poor
Toughness	Very good-fair	Fair	Fair	Very good	Fair	Poor	Poor	Poor
Wear Res	Good-fair	Fair	Good	Fair	Good	Good	Very good	Very good
Machinability	Good	Good	Good	Fair	Good	Good	Fair	Fair
Res to Decarb	Good	Good	Good	Good	Good	Good	Good	Good
REMARKS AND USES	Deeper hardening characteristics than W grades and about same properties as O1 and O2, but greater tendency to distort; all types of dies					Very good abrasion resistance with consequent difficulty in grinding; generally limited to wire, bar or tube cold-drawing die and finishing tools		

AISI Type →	Special Purpose Tool Steels—Mold Steels (P)						
	P1	P2	P3	P4	P5	P6	P20
COMPOSITION, %	C 0.10	C 0.07, Cr 2.00, Ni 0.50, Mo 0.20	C 0.10, Cr 0.60, Ni 1.25	C 0.07, Cr 5.00	C 0.10, Cr 2.25	C 0.10, Cr 1.50, Ni 3.50	C 0.30, Cr 0.75, Mo 0.25
HEAT TREATMENTS							
Forging Temp, F	1450–1550 or 2200–2350	1850–2050	1850–2050	1850–2050	1850–2050	1950–2150	1850–2050
Anneal Temp, F	1350–1650	1350–1500	1350–1500	1600–1650	1550–1600	1550	1400–1450
Hard. Temp, F	1450–1475	1525–1550	1475–1525	1775–1825	1550–1600	1450–1500	1500–1600
Quench Medium[a]	W or B	O	O	A	O or W	O	O
Temper Temp, F	300–500	300–500	300–500	300–500	300–500	300–450	300–500
Hardness, Rockwell	C64–58	C64–58	C64–58	C64–58	C64–50	C58–61	C64–58
SERVICE PROPERTIES							
Depth of Hard	Shallow	Shallow	Shallow	Shallow	Shallow	Deep	Medium
Nondeformability	Poor	Good	Good	—	Good	Good	Good
Safety in Hard	Fair	Good	Good	—	Good	Good	Good
Toughness	Good	Good	Good	—	Good	Good	Good
Wear Res	Good	Good	Good	—	Good	Good	Fair-good
Machinability	Poor	Good	Fair	—	Fair	Fair	Good
Res to Decarb	Good	Good	Good	—	Good	Good	Good
REMARKS AND USES	P1 is easily hubbed, has low cure hardness, is subject to distortion; P4 and P5 more difficult to hub but relatively nondeforming; P2, P3 and P6 very difficult to hub; primarily as plastic mold steels						

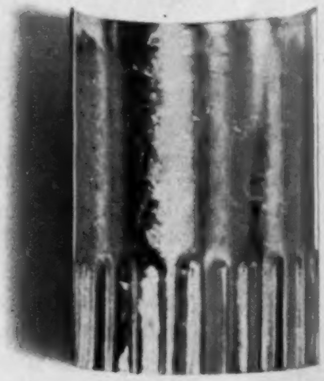
[a] W = water; B = brine; O = oil; A = air.

...seam it



...dovetail it

...weld it



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...slit it

...draw it

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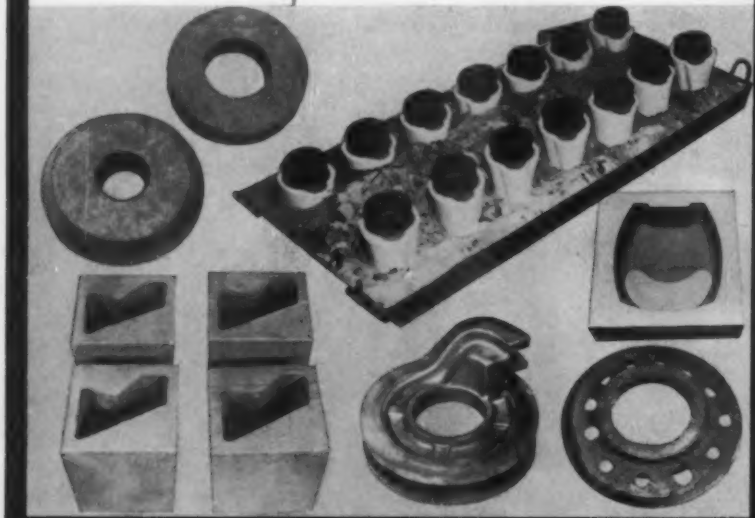

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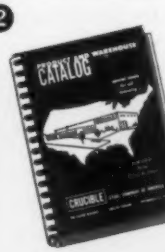

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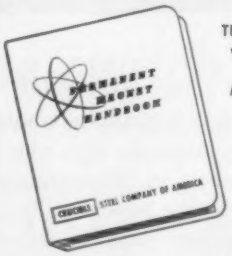

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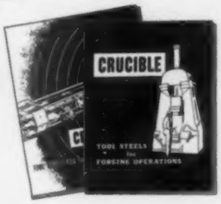

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"With strip we use smaller blanks to produce the same part."

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"Strip saves us metal. We can use smaller blanks to produce the same part. I'd say we save from $\frac{1}{16}$" to $\frac{3}{32}$" of metal per part. That's a lot of steel when you're turning out 25-30 million parts a year.

"We don't have gauge problems now. The strip we buy is always rolled within our working tolerance. We work to a plus or minus .0025 inches.

"So far, strip hasn't given us lamination troubles. It doesn't take much lamination to give you big trouble in a deep drawing operation. When the metal separates, part may stick to the punch while part stays in the cavity. As another blank transfers to the same station, there's a double smash and the die is ruined. That hasn't happened with strip. Saves a lot of downtime and die repair.

"Strip takes a deep draw without thinning out on you. Its uniform temper pays off when you're turning out Silent Blocks where both the ID and OD have to be right or the part's a reject.

"All in all our rejects have dropped from about 8% to less than 1% since we switched back to strip.

This mark tells you a product is made of modern, dependable Steel.

SUPPLIERS' LITERATURE

NONFERROUS METALS

High Strength Aluminum. American Smelting & Refining Co., Federated Metals Div., 8 pp, illus., No. 103R5. Composition, specifications, mechanical properties, dimensional stability, corrosion resistance machining and polishing, finishing, joining, foundry practices, typical applications, and other information on a high strength aluminum casting alloy. **35**

Copper-Nickel-Silicon Alloy. Anaconda American Brass Co., 2 pp. Advantages, properties, composition, and other data on a copper-nickel-silicon alloy used in electrical equipment. **36**

Beryllium Copper Strip. Beryllium Corp., 12 pp, illus., No. S-1100-A. Typical applications, advantages, and fabrication data for five beryllium copper alloys. Includes physical and mechanical properties before and after heat treatment, and information on how to select the right beryllium copper alloy to meet specific requirements. **37**

Tellurium Copper. Bridgeport Brass Co. Physical, mechanical and fabrication properties, and applications of tellurium copper. **38**

Low Melting Alloys. Cerro Sales Corp., 8 pp, illus., No. J4. Sixty-three applications of low melting Cerro Alloys in the metalworking field. **39**

Copper and Brass Products. C. G. Hussey & Co., Div. of Copper Range Co., 30 pp, illus. Information on sizes, dimensions, weights, etc. of standard copper and brass mill products, including sheet, strip, rod, wire, tubing and pipe, roofing materials, and various shapes. **41**

Aluminum Selector Chart. Fairmont Aluminum Co., 6 pp. Strength, thermal and electrical conductivity, density, specific gravity, melting range, weight, tolerances, fabrication characteristics, available finishes, hardening properties, embossing designations, and typical uses for ten most used aluminum alloys. **42**

Refractory Metals. Fansteel Metallurgical Corp., 2 pp, illus., No. F-1152-1. Chart gives complete properties of tungsten, tantalum, molybdenum and columbium. Included is a temperature conversion chart which covers the entire range from absolute zero to 6512 F. **43**

Aluminum Alloy. Frontier Bronze Corp., 24 pp, illus. Describes Alloy 40-E, a high strength aluminum alloy that needs no heat treatment. **44**

Tungsten, Molybdenum. General Electric Co., Lamp Metals & Components Dept., 80 pp, illus. Properties, structure, finishes, uses, availability, and prices of tungsten and molybdenum metal powders, rod, and wire. **45**

Silver Alloy Brazing. Handy & Harman, 4 pp, illus. Examples of the use of silver alloy brazing to join various components and products involving similar and dissimilar metals. **46**

Wire Cost Calculator. Hoskins Mfg. Co. Pocket-size calculator provides megohms-per-lb and cost-per-megohm of enameled nickel-chromium and iron-chromium-aluminum precision resistor wire. **47**

Cobalt-Base Superalloy. Howe Sound Co., WaiMet Alloys Co., Div., 4 pp, illus., No. 362-T. Composition, mechanical properties, and stress-rupture properties of a cobalt-base superalloy casting alloy. **48**

Indium. Indium Corp. of America, 4 pp, illus. Advantages, characteristics, uses, properties and other information on indium. **49**

Beryllium Copper Springs. Instrument Specialties Co., Inc., 20 pp, illus., No. 11. Characteristics, advantages, tolerances, and uses of beryllium copper compression springs, flat springs, strip springs, finger contact strips, contact rings, and other parts. **50**

History of Metals. Kaiser Aluminum & Chemical Corp., 32 pp, illus., Jan-Feb '61. Interesting booklet describes major developments in the history of metals, especially aluminum. Includes a chronology of metals, covering discovery, application, and supporting arts, from 5300 B.C. to the present. **51**

Uses of Tin. Malayan Tin Bureau, 20 pp, illus. Detailed descriptions of several uses of tin including tinplate, solder, bronze, babbitt, white metals, tinning, tubes, chemicals, etc. **52**

Copper Powder. Malone Metal Powders, Inc., 4 pp, illus. Describes Fernlock Copper, made by electrolysis and having a dendritic particle shape and low density. **53**

Phosphor Bronze. Miller Co., Rolling Mill Div., 20 pp, illus. Mechanical and physical properties of a line of phosphor bronzes. Included is a discussion of services and facilities available for the production of phosphor bronze parts. **54**

Aluminum Alloy Selector. Olin Mathieson Chemical Corp., Metals Div., 24 pp, illus., No. OA-11. Physical properties, fabrication characteristics and economic advantages of a wide variety of aluminum sheet, plate, rod, bar, extrusion and casting alloys. **55**

Electrical, Electronic Alloys. H. K. Porter Co., Inc., Riverside-Alloy Metal Div., 8 pp, illus., No. A-30. Advantages, properties, characteristics, and typical applications of several groups of alloys used in electrical and electronic industries. **56**

Aluminum and Its Alloys. Joseph T. Ryerson & Son, Inc., 20 pp, illus., No. 30-1. Specifications, analyses, mechanical properties, tolerances, machinability ratings, finishes, corrosion resistance, and relative costs of aluminum foil, sheet, plate, tubing, pipe, rod and bar. **57**

Zinc Alloys. St. Joseph Lead Co., 22 pp, illus. Discusses zinc die casting alloys and commercial finishes for zinc die castings. **58**

Brass, Aluminum Products. Scovill Mfg. Co., Mill Products Div., 12 pp, illus. Information on such products as brass sheet, strip and rod; aluminum sheet and rod; metal stampings; and aircraft fasteners. **59**

Thin Strip. Somers Brass Inc., 4 pp, illus., No. R-1-758. Specifications, available ferrous and nonferrous alloys, and other data on precision rolled thin strip. **60**

High Temperature Alloys. Haynes Stellite Co., Div. of Union Carbide Corp., 20 pp, illus., No. F30,134. Series of charts compare physical, mechanical, chemical, and stress rupture properties of 17 high temperature alloys. **61**

Refractory Metals. Wah Chang Corp., 4 pp, illus. General information on the services and facilities available for the production of refractory metals. Includes information on available products and typical uses for tungsten, molybdenum, columbium, tantalum, zirconium, and hafnium. **63**

High Temperature Alloys. Westinghouse Electric Corp., Materials Mfg. Dept., 4 pp, illus., No. 52-250. Advantages, characteristics, applications, properties, availability, fabrication data, heat treatment, and other information on two precipitation hardening superalloys. **64**

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NONFERROUS METALS

NONFERROUS METALS

Aluminum and Its Alloys—Wrought

Type →	EC	1100	3003	3004
COMPOSITION, %	Al 99.45 min	Al 99.0 min	Mn 1.0–1.5	Mn 1.0–1.5, Mg 0.8–1.3
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.098	0.098	0.099	0.098
Melting Temp Range, F	1195–1215	1190–1215	1190–1210	1165–1205
Ther Cond (77 F, ann.), Btu/hr/sq ft/°F/ft	135	128	111	93.8
Coef of Ther Exp (68 to 212 F), per °F	13.2×10^{-6}	13.1×10^{-6}	12.9×10^{-6}	13.3×10^{-6}
Spec Heat (212 F), Btu/lb/°F	—	0.22	0.22	0.22
Elec Res (68 F), microhm-cm				
Annealed	2.8	2.92	3.45	4.10
Hard (H18 or H38)	2.8	3.02	4.31	4.10
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	10×10^6	10×10^6	10×10^6	10×10^6
Ten Str (75 F), 1000 psi				
Annealed (O)	12	13	16	26
Half Hard	16 (H14)	18 (H14)	22 (H14)	35 (H34)
Hard	27 (H19)	24 (H18)	29 (H18)	41 (H38)
Yld Str (75 F), 1000 psi				
Annealed (O)	4	5	6	10
Half Hard	14 (H14)	17 (H14)	21 (H14)	29 (H34)
Hard	24 (H19)	22 (H18)	27 (H18)	36 (H38)
Elong (in 2 in., 75 F), %[a]				
Annealed (O)	23[d]	35, 45	30, 40	20, 25
Half Hard	—	9, 20 (H14)	8, 16 (H14)	9, 12 (H34)
Hard	1.5[d] (H19)	5, 15 (H18)	4, 10 (H18)	5, 6 (H38)
Hardness (Brinell)[b]				
Annealed (O)	—	23	28	45
Half Hard	—	32 (H14)	40 (H14)	63 (H34)
Hard	—	44 (H18)	55 (H18)	77 (H38)
Endurance Limit, 1000 psi				
Annealed (O)	—	5	7	14
Half Hard	—	7 (H14)	9 (H14)	15 (H34)
Hard	7 (H19)	9 (H18)	10 (H18)	16 (H38)
Shear Str, 1000 psi				
Annealed (O)	8	9	11	16
Half Hard	10 (H14)	11 (H14)	14 (H14)	18 (H34)
Hard	15 (H19)	13 (H18)	16 (H18)	21 (H38)
FABRICATING PROPERTIES				
Annealing Temp, F	650	650	775	650
Hot Working Temp Range, F	—	500–950	500–950	500–950
Machinability	Fair	Good	Good	Good
Relative Weldability[c]				
Torch	A	A	A	B
Inert Arc	A	A	A	A
Electrical Resistance	A	A	A	A
CORROSION RESISTANCE	High resistance to rural, industrial and marine atmospheres. Good resistance to most neutral or nearly neutral fresh waters; sea water; many foodstuffs; organic acids and anhydrides; alcohols; aldehydes; esters; ketones; oils, gasoline, greases, waxes, and other petroleum derivatives; ammonia and ammonium compounds; nitric acid above 82%; essential oils; amides; nitroparaffins; coal tar derivatives; hydrogen peroxide; and many neutral aqueous inorganic salt solutions			
AVAILABLE FORMS	Sheet, plate, wire, rod, bar, tube			
	Foil, extrusions, structural shapes, pipe	Rivets, forgings, impacts, extrusions	Extruded shapes, tubing, forgings, pipe	Sheet, plate
USES	Electrical conductors	Cooking utensils, heat exchangers, pressure and storage tanks		Hydraulic tubing for commercial vehicles, storage tanks, lamp bases, roofing, architectural applications
		Chemical equipment, reflectors, sheet-metal work	Ductwork, truck panels, architectural applications, builders' hardware	

[a] Values given for $^1/_{16}$-in. sheet and ½-in. bar, in that order. [b] 500-kg load, 10-mm ball.
[c] Letter A indicates most favorable, B less favorable, etc. Values relative to aluminum alloys only.
[d] Elongation (in 10 in.) for wire.

Aluminum and Its Alloys—Wrought

Type →	2011	2014[a]	2017	2024[c]
COMPOSITION, %	Cu 5.0–6.0, Pb 0.2–0.6, Bi 0.2–0.6	Cu 3.9–5.0, Si 0.5–1.2, Mn 0.4–1.2, Mg 0.2–0.8	Cu 3.5–4.5, Mn 0.4–1.0, Mg 0.2–0.8	Cu 3.8–4.9, Mn 0.3–0.9, Mg 1.2–1.8
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.102	0.101	0.101	0.100
Melting Temp Range, F	995–1190	950–1180	955–1185	935–1180
Ther Cond (77 F, annealed), Btu/hr/sq ft/°F/ft	82.5	111.0	99.4	109.2
Coef of Ther Exp, per °F				
68 to 212 F	12.8×10^{-6}	12.8×10^{-6}	13.1×10^{-6}	12.9×10^{-6}
68 to 572 F	13.9×10^{-6}	13.6×10^{-6}	13.9×10^{-6}	13.7×10^{-6}
Spec Heat, Btu/lb/°F	0.23	0.22	0.22	0.22
Elec Res (68 F), microhm-cm	4.8 (T3)	3.45 (O), 4.31 (T6)	3.83 (O), 5.75 (T4)	3.45 (O), 5.75 (T4)
MECHANICAL PROPERTIES[d]				
Mod of Elast in Tension, psi	10.2×10^6	10.6×10^6	10.5×10^6	10.6×10^6
Ten Str, 1000 psi				
Annealed (O)	—	27	26	27
Heat Treated	55 (T3), 59 (T8)	62 (T4), 70 (T6)	62 (T4)	70 (T3)
Yld Str (0.2% offset), 1000 psi				
Annealed (O)	—	14	10	11
Heat Treated	43 (T3), 45 (T8)	42 (T4), 60 (T6)	40 (T4)	50 (T3)
Elong (in 2 in.), %				
Annealed (O)	—	18	22	20[f]
Heat Treated	15 (T3), 12 (T8)	20 (T4), 13 (T6)	22 (T4)	18 (T3)[f]
Hardness (Brinell)				
Annealed (O)	—	45	45	47
Heat Treated	95 (T3), 100 (T8)	105 (T4), 135 (T6)	105 (T4)	120 (T3)
Endurance Limit, 1000 psi				
Annealed (O)	—	13	13	13
Heat Treated	18 (T3), 18 (T8)	20 (T4), 18 (T6)	18 (T4)	20 (T3)
Shear Str, 1000 psi				
Annealed (O)	—	18	18	18
Heat Treated	32 (T3), 35 (T8)	38 (T4), 42 (T6)	38 (T4)	41 (T3)
FABRICATING PROPERTIES				
Annealing Temp, F	775	775	775	775
Solution Temp, F	950	940	940	920
Aging Temp, F	320	340	—	375
Machinability[e]	A (T3, T8)	A (T6)	A (T4)	A (T3)
Relative Weldability[e]				
Torch	D	D	D	D
Inert Arc	D	B	B	B
Electrical Resistance	B	B	B	B
CORROSION RESISTANCE	Compared to other aluminum alloys, this group has high resistance to rural atmospheres, fairly good resistance to industrial atmospheres, and poor resistance to marine atmospheres and sea water. More susceptible to corrosive attack than other groups of wrought aluminum alloys. Both degree and nature of the attack are greatly influenced by thermal treatment. Clad sheet alloys generally have high corrosion resistance			
AVAILABLE FORMS	Rod, bar, wire	Sheet, plate, extruded shapes, structural shapes, forgings, rod, bar	Rod, bar, wire, rivets	Sheet, plate, rod, bar, tube, pipe, wire, rivets, extruded shapes
USES	Screw machine products	Heavy duty forgings, power shovel bails, airplane fittings, structural members	Screw machine products	Screw machine products, aircraft applications

[a] 2014 available clad with 6053.
[c] 2024 available clad with aluminum of 99.3% min purity.
[d] Values given on 1/16-in. sheet and 1/2-in. bar, in that order.
[e] Letter A indicates most favorable, B less favorable, etc. Relative to aluminum alloys only.
[f] Elongation (in 10 in.) for wire.

continued on next page

Aluminum and Its Alloys—Wrought

Type ➔	5005	5050	5052	5056
COMPOSITION, %	Mg 0.5–1.1	Mg 1.0–1.8	Mg 2.2–2.8, Cr 0.15–0.35	Mn 0.05–0.20, Mg 4.5 5.6, Cr 0.05–0.20
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.097	0.097	0.097	0.095
Melting Temp Range, F	1170–1205	1160–1205	1100–1200	1055–1180
Ther Cond (77 F, ann.), Btu/hr/sq ft/°F/ft	116	111	80.0	67.4
Coef of Ther Exp, per °F				
68 to 212 F	13.3×10^{-6}	13.2×10^{-6}	13.2×10^{-6}	13.4×10^{-6}
68 to 572 F	—	14.2×10^{-6}	14.3×10^{-6}	14.5×10^{-6}
Spec Heat (212 F), Btu/lb/°F	0.23	0.22	0.22	0.22
Elec Res (68 F), microhm-cm				
Annealed	3.3	3.4	4.93	5.94
Hard (H18 or H38)	3.3	3.4	4.93	6.39
MECHANICAL PROPERTIES				
Mod of Elasticity in Tension, psi	10×10^6	10×10^6	10.2×10^6	10.3×10^6
Ten Str (75 F), 1000 psi				
Annealed (O)	18	21	28	42
Half Hard	23 (H14)	28 (H34)	38 (H34)	—
Hard	29 (H18)	32 (H38)	42 (H38)	60 (H38)
Yld Str (75 F), 1000 psi				
Annealed (O)	6	8	13	22
Half Hard	22 (H14)	24 (H34)	31 (H34)	—
Hard	28 (H18)	29 (H38)	37 (H38)	50 (H38)
Elong (in 2 in., 75 F), %[a]				
Annealed (O)	30, —	24	25, 30	—, 35
Half Hard	6, — (H14)	8 (H34)	10, 14 (H34)	—
Hard	4, — (H18)	6 (H38)	7, 8 (H38)	—, 15 (H38)
Hardness (Brinell)[b]				
Annealed (O)	28	36	47	65
Half Hard	41 (H34)	53 (H34)	68 (H34)	—
Hard	51 (H38)	63 (H38)	77 (H38)	105(H18),100(H38)
Endurance Limit, 1000 psi				
Annealed (O)	—	12	16	20
Half Hard	—	13 (H34)	18 (H34)	—
Hard	—	14 (H38)	20 (H38)	22 (H38)
Shear Str, 1000 psi				
Annealed (O)	11	15	18	26
Half Hard	14 (H14)	18 (H34)	21 (H34)	—
Hard	16 (H18)	20 (H38)	24 (H38)	32 (H38)
FABRICATING PROPERTIES				
Annealing Temp, F	650	650	650	650
Hot Working Temp Range, F	—	—	500–950	500–950
Machinability	Good	Good	Good	Good
Relative Weldability[c]				
Torch	A	A	A	C
Inert Arc	A	A	A	A
Electrical Resistance	A	A	A	A
CORROSION RESISTANCE	High resistance to rural, industrial and marine atmospheres. Good resistance to most neutral or nearly neutral fresh waters; sea water; many foodstuffs; organic acids and anhydrides; alcohols; aldehydes; esters; ketones; oils, gasoline, greases, waxes, and other petroleum derivatives; ammonia and ammonium compounds; nitric acid above 82%; essential oils; amides; nitroparaffins; coal tar derivatives; hydrogen peroxide; and many neutral aqueous inorganic salt solutions			
AVAILABLE FORMS	Foil, sheet, plate, rod	Sheet, plate, drawn tube, rod, bar, wire	Sheet, plate, wire, rod, bar, drawn tube, rivets	Rod, wire, rivets
USES	Appliances, cooking utensils, architectural applications	Decorative refrigerator parts, coiled tubes, builders' hardware	Bus and truck bodies, aircraft tubing, milk crates, fan blades, kitchen cabinets, marine applications, street and light standards, chemical drums	Braided cable armor, rivets for magnesium, screens

[a] Values given for 1/16-in. sheet and 1/2-in. bar, in that order. [b] 500-kg load, 10-mm ball.
[c] Letter A indicates most favorable, B less favorable, etc. Values relative to aluminum alloys only.

Aluminum and Its Alloys—Wrought

Type ➜	5083	5086	5154	5456
COMPOSITION, %	Mg 4.0–4.9, Mn 0.3–1.0, Cr 0.05–0.25	Mg 3.5–4.5, Mn 0.2–0.7, Cr 0.05–0.25	Mg 3.1–3.9, Cr 0.15–0.35	Mg 4.7–5.5, Mn 0.5–1.0, Cr 0.05–0.20
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.096	0.096	0.096	0.096
Melting Temp Range, F	1060–1180	1084–1184	1100–1190	1060–1180
Ther Cond (77 F, ann.), Btu/hr/sq ft/°F/ft	68	73	73	68
Coef of Ther Exp (68–212 F), per °F	13.2×10^{-6}	13.2×10^{-6}	13.3×10^{-6}	13.3×10^{-6}
Spec Heat (212 F), Btu/lb/°F	0.23	0.23	0.23	0.23
Elec Res (68 F), microhm-cm				
Annealed	5.9	5.5	5.3	5.9
Hard	—	5.5	5.3	—
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	10.3×10^6	10.3×10^6	10.2×10^6	10.3×10^6
Ten Str (75 F), 1000 psi				
Annealed (O)	42	38	35	45
Half Hard	46 (H113)	47 (H34)	42 (H34)	51 (H321)
Hard	—	—	48 (H38)	—
Yld Str (75 F), 1000 psi				
Annealed	21	17	17	23
Half Hard	33 (H113)	37 (H34)	33 (H34)	37 (H321)
Hard	—	—	39 (H38)	—
Elong (in 2 in., 75 F), %[a]				
Annealed (O)	22, —	22, —	27, —	24, —
Half Hard	16 (H113), —	10 (H34), —	13 (H34), —	16 (H321), —
Hard	—	—	10 (H38), —	—
Hardness (Brinell)[b]				
Annealed (O)	—	—	58	75
Half Hard	—	—	73 (H34)	90 (H321)
Hard	—	—	80 (H38)	—
Endurance Limit, 1000 psi				
Annealed (O)	—	—	17	—
Half Hard	23 (H113)	16 (H34)	19 (H34)	—
Hard	—	—	21 (H38)	—
Shear Str, 1000 psi				
Annealed (O)	25	23	22	28
Half Hard	—	27 (H34)	24 (H34)	30 (H321)
Hard	—	—	28 (H38)	—
FABRICATING PROPERTIES				
Annealing Temp, F	650	650	650	650
Machinability	D	D	D	D
Relative Weldability[d]				
Torch	D	C	C	D
Inert Arc	A	A	A	A
Electrical Resistance	B	A	B	B
CORROSION RESISTANCE	High resistance to rural, industrial and marine atmospheres. Good resistance to most neutral or nearly neutral fresh waters; sea water; many foodstuffs; organic acids and anhydrides; alcohols; aldehydes; esters; ketones; oils, gasoline, greases, waxes, and other petroleum derivatives; ammonia and ammonium compounds; nitric acid above 82%; essential oils; amides; nitroparaffins; coal tar derivatives; hydrogen peroxide; and many neutral aqueous inorganic salt solutions			
AVAILABLE FORMS	Plate, extrusions, sheet, structural shapes, bar, rod	Sheet, plate, extrusions, structural shapes, rod, bar	Sheet, plate, welding wire, pipe, rod, bar, tube, extrusions	Sheet, plate, extrusions, rods, bar, structural shapes, tube
USES	Unfired pressure vessels, marine superstructures, decks and hulls, auto frames, aircraft landing gears, TV structural towers, drilling rigs, welded assemblies	Transportation equipment, welded construction, unfired pressure vessels, guided missile containers	Unfired pressure vessels, welded construction, storage tanks, truck and marine applications	Deck housing, heavy duty structures, overhead cranes, gun mounts, pressure vessels, storage tanks

[a] Values given for 1/16-in. sheet and 1/2-in. bar in that order. [b] 500-kg load, 10-mm ball.
[d] Letter A indicates most favorable, B less favorable, etc. Values relative to aluminum alloys only.
[e] Rockwell hardness.

continued on next page

Aluminum and Its Alloys—Wrought

Type →	6061	6063	7075	7079	7178
COMPOSITION, %	Mg 0.8–1.2, Si 0.4–0.8, Cr 0.15–0.35, Cu 0.15–0.40	Mg 0.45–0.9, Si 0.2–0.6	Zn 5.1–6.1, Mg 2.1–2.9, Cu 1.2–2.0, Cr 0.18–0.40	Zn 3.8–4.8, Mg 2.9–3.7, Cu 0.4–0.8, Mn 0.1–0.3, Cr 0.1–0.25	Zn 6.3–7.3, Mg 2.4–3.1, Cu 1.6–2.4, Mn 0.30, Cr 0.18–0.40
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.098	0.098	0.101	0.099	0.102
Melting Temp Range, F	1080–1200	1140–1205	890–1180	900–1180	890–1165
Ther Cond (77 F), Btu/hr/sq ft/°F/ft	99	111	70 (T6)	70 (T6)	70 (T6)
Coef of Ther Exp, per °F					
68-212 F	13.0×10^{-6}	13.0×10^{-6}	13.1×10^{-6}	13.1×10^{-6}	13.0×10^{-6}
68-572 F	14.1×10^{-6}	14.2×10^{-6}	14.4×10^{-6}	14.2×10^{-6}	—
Specific Heat, Btu/lb/°F	0.23	—	0.23	—	—
Elec Res (68 F), microhm-cm	3.8 (O)	3.3 (T6)	5.7 (T6)	5.5 (T6)	5.5 (T6)
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	10.0×10^{6}	10.0×10^{6}	10.4×10^{6}	10.3×10^{6}	10.4×10^{6}
Ten Str, 1000 psi					
Annealed (O)	18	13	33	—	33
Heat Treated	35 (T4), 45 (T6)	25 (T4), 35 (T6)	83 (T6)	78 (T6)	88 (T6)[b]
Yld Str (0.2% offset), 1000 psi					
Annealed (O)	8	7	15	—	15
Heat Treated	21 (T4), 40 (T6)	13 (T4), 31 (T6)	73 (T6)	68 (T6)	78 (T6)[b]
Elong (in 2 in.), %					
Annealed (O)	25, 30	—	17, 16	—	15–16
Heat Treated	22 (T4), 12 (T6)	22 (T4), 12 (T6)	11 (T6)	14 (T6)	10–11 (T6)
Hardness (Brinell)					
Annealed (O)	30	25	60	—	60
Heat Treated	65 (T4), 95 (T6)	—, 73 (T6)	150 (T6)	145 (T6)	160 (T6)
Endurance Limit, 1000 psi					
Annealed (O)	9	8	—	—	—
Heat Treated	14 (T4), 14 (T6)	—, 10 (T6)	23 (T6)	23 (T6)	—
Shear Str, 1000 psi					
Annealed (O)	12	10	22	—	22
Heat Treated	24 (T4), 30 (T6)	—, 22 (T6)	48 (T6)	45 (T6)	52
FABRICATING PROPERTIES					
Annealing Temp, F	775	775	775	775	775
Solution Temp, F	970	—	870	830	870
Aging Temp, F	320–350	350–450	250	230–250	250
Machinability[a]	B (T4, T6)	B (T4, T6)	A (T6)	A (T6)	A (T6)
Relative Weldability[a]					
Torch	A	A	D	D	D
Inert Arc	A	A	D	D	C
Elec Res	A	A	B	C	B
CORROSION RESISTANCE	Compared with other aluminum alloys, these alloys have high resistance to rural atmospheres, good resistance to industrial and marine atmospheres. Degree and nature of attack in other environments is greatly influenced by heat treatment. Clad alloys have corrosion resistance of the cladding alloy		Compared with other aluminum alloys, these alloys have good corrosion resistance to rural atmospheres but are attacked by industrial and marine atmospheres. In other environments, they are generally less corrosion resistant than other wrought aluminum alloys and are frequently clad. Clad alloys have corrosion resistance of the cladding alloy		
AVAILABLE FORMS	Sheet, plate, wire, rod, bar, pipe, tubing, extruded shapes, forgings	Extruded shapes, tube, pipe	Sheet, plate, wire, rod, bar, extruded shapes, tube, pipe, forgings	Forgings, extrusions, plate	Sheet, plate, extrusions, rod, bar
USES	Transportation equipment, heavy duty structures, marine uses, pipe, furniture, bridge rail	Pipe, railings, hardware, architectural uses	Structural parts for aircraft		Structural parts in aircraft

[a] Letter A indicates most favorable, B less favorable, etc. Relative to aluminum alloys only.
[b] Extruded products will have strengths approximately 10% higher.

Aluminum and Its Alloys—Cast

Type →	195	B195	108	A108
COMPOSITION, %	Cu 4.5, Al bal	Cu 4.5, Si 2.5, Al bal	Cu 4.0, Si 3.0, Al bal	Cu 4.5, Si 5.5, Al bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.101	0.100	0.101	0.101
Solid. Temp Range, F	1190–970	1190–970	1160–970	1135–970
Ther Cond (as cast. 68 F), Btu/hr/sq ft/°F/ft	82.5	92.5	70	82
Coef of Ther Exp (68–212 F), per °F	12.7×10^{-6}	12.2×10^{-6}	12.2×10^{-6}	11.9×10^{-6}
Elec Cond (as cast), % IACS	36	42.5	31	37
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
As Cast	—	—	21	28
Sol'n Heat Treated	32	37	—	—
Sol'n Treated & Aged	36	40	—	—
Yld Str (0.2% offset), 1000 psi				
As Cast	—	—	14	16
Sol'n Heat Treated	16	19	—	—
Sol'n Treated & Aged	24	26	—	—
Elong (in 2 in.), %				
As Cast	—	—	2.5	2.0
Sol'n Heat Treated	8.5	9.0	—	—
Sol'n Treated & Aged	5.0	5.0	—	—
Hardness (Brinell)				
As Cast	—	—	55	70
Sol'n Heat Treated	60	75	—	—
Sol'n Treated & Aged	75	90	—	—
Endurance Limit, 1000 psi				
Sol'n Heat Treated	7	9.5	—	—
Sol'n Treated & Aged	8	10.0	—	—
Compr Yld Str, 1000 psi				
As Cast	—	—	15	17
Sol'n Heat Treated	17	20	—	—
Sol'n Treated & Aged	25	26	—	—
Shear Str, 1000 psi				
As Cast	—	—	17	22
Sol'n Heat Treated	26	30	—	—
Sol'n Treated & Aged	30	32	—	—
THERMAL TREATMENT				
Annealing Temp, F	650	650	650	650
Solution Temp, F	960	950	—	—
Aging Temp, F	310	310	—	—
FABRICATING PROPERTIES				
Machinability[b]	AB	AB	B	B
Weldability[b]				
Gas	C	C	B	A
Arc	B	B	D	A
Resistance	B	B	B	A
CORROSION RESISTANCE	Good corrosion resistance; alloys containing silicon are superior. In general: Resistant to nitric, chromic and most organic acids; attacked by hydrochloric and sulfuric acids. Resistant to ammonium hydroxide; attacked by sodium, potassium and calcium hydroxides. Resistant to many salts, but attacked by salts of heavy metals. Resistant to attack by industrial and marine atmospheres			
AVAILABLE FORMS	Sand castings	Permanent mold castings[a]	Sand castings	Permanent mold castings
USES	Crankcases, bus wheels, housings, spring hangers, fittings	Aircraft fittings, fuel pump bodies, gear housings, seat frames	Manifolds, valve bodies, pressure-tight parts	Parts requiring pressure tightness, ornamental grilles

[a] General purpose castings. [b] A = excellent, AB = very good, B = good, C = fair, D = poor.

continued on next page

Aluminum and Its Alloys—Cast

Type ➔	214	220	43	356
COMPOSITION, %	Mg 4.0, Al bal	Mg 10.0, Al bal	Si 5.25, Al bal	Si 7.0, Mg 0.40, Al bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.096	0.093	0.097	0.097
Solid. Temp Range, F	1185–1110	1120–840	1170–1065	1135–1035
Ther Cond (as cast, 68F), Btu/hr/sq ft/°F/ft	80	51	85	92
Coef of Ther Exp (68–212 F), per °F	13.3×10^{-6}	13.6×10^{-6}	12.2×10^{-6}	11.9×10^{-6}
Elec Cond (as cast), % IACS	35	21	38	41
MECHANICAL PROPERTIES[f]				
Ten Str, 1000 psi				
As Cast	25	—	19	—
Sol'n Heat Treated	—	48	—	—
Aged[g]	—	—	—	25, 38
Yld Str (0.2% offset), 1000 psi				
As Cast	12	—	8	—
Sol'n Heat Treated	—	26	—	—
Aged[g]	—	—	—	20, 27
Elong (in 2 in.), %				
As Cast	9.0	—	8	—
Sol'n Heat Treated	—	16	—	—
Aged[g]	—	—	—	2.0, 5.0
Hardness (Brinell)				
As Cast	50	—	40	—
Sol'n Heat Treated	—	75	—	—
Aged[g]	—	—	—	60, 80
Endurance Limit, 1000 psi				
As Cast	7	—	8	—
Sol'n Heat Treated	—	8	—	8.0, 13
Compr Yld Str, 1000 psi				
As Cast	12	—	9	—
Sol'n Heat Treated	—	27	—	—
Aged[g]	—	—	—	21, 27
Shear Str, 1000 psi				
As Cast	20	—	14	—
Sol'n Heat Treated	—	34	—	20, 30
THERMAL TREATMENT				
Annealing Temp, F	650	650	650	650
Solution Temp, F	—	810	—	1000
Aging Temp, F	—	—	—	310
FABRICATING PROPERTIES				
Machinability[e]	A	A	C	AB
Weldability[e,f]				
Gas	B	D	A, —	AB, AB
Arc	A	C	A, —	AB, AB
Resistance	B	B	A, —	AB, AB
CORROSION RESISTANCE	Very good corrosion resistance; alloys containing silicon are superior. In general: Resistant to nitric, chromic and most organic acids; attacked by hydrochloric and sulfuric acids. Resistant to ammonium hydroxide; attacked by sodium, potassium and calcium hydroxides. Resistant to many salts, but attacked by salts of heavy metals. Resistant to attack by industrial and marine atmospheres			
AVAILABLE FORMS	Sand castings	Sand castings	Sand and perm mold castings	Sand and perm mold castings
USES	Dairy and food handling equipment, cooking utensils, chemical fittings, hardware	Aircraft fittings, levers, brackets, parts requiring shock resistance	Sand—marine fittings, food handling equipment, pipe fittings. Permanent mold — refrigerator fittings, carburetor bodies, thin-section general purpose castings	Automotive transmission cases, housings, aircraft fittings, marine hardware, bridge rail parts, truck axle housings, wheels

[b] Corrosion resistant castings. [e] A = excellent, AB = very good, B = good, C = fair, D = poor.
[f] Where two values are given they refer to sand and permanent mold castings, respectively.
[g] First value obtained by artificial aging; second value by solution treating and aging.

Aluminum and Its Alloys—Cast

Type ➡	122	142	355	40-E
COMPOSITION, %	Cu 10.0, Mg 0.25, Al bal	Cu 4.0, Mg 1.5, Ni 2.0, Al bal	Cu 1.25, Si 5.0, Mg 0.5, Al bal	Zn 5.5, Mg 0.6, Cr 0.5, Ti 0.15, Al bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.107	0.102	0.098	0.100
Solid. Temp Range, F	1155–965	1175–990	1150–1015	1140–1060
Ther Cond (as cast, 68 F), Btu/hr/sq ft/°F/ft	77	87	87	80
Coef of Ther Exp (68–212 F), per °F	12.2×10^{-6}	12.5×10^{-6}	12.4×10^{-6}	13.7×10^{-6}
Elec Cond (as cast), % IACS	33	38.5	39	25
MECHANICAL PROPERTIES[f]				
Tensile Strength, 1000 psi				
Artificially Aged	27, 37	27, 40	28, 30	35
Sol'n Treated & Aged	40, 48	28, 47	35, 42	—
Yield Strength (0.2% offset), 1000 psi				
Artificially Aged	30, 35	18, 34	23, 24	25
Sol'n Treated & Aged	20, 36	25, 42	25, 27	—
Elongation (in 2 in.), %				
Artificially Aged	1.0, <0.5	1.0, 1.0	1.5, 2.0	3.0
Sol'n Treated & Aged	0.5, <0.5	2.0, 0.5	3.0, 4.0	—
Hardness (Brinell)				
Artificially Aged	80, 115	70, 105	65, 75	60-75
Sol'n Treated & Aged	115, 140	75, 110	80, 90	—
Endurance Limit, 1000 psi				
Artificially Aged	9.5, 8.5	6.5, 10.5	8, 7	10
Sol'n Treated & Aged	8.5, 9	9.5, 9.5	9, 10	—
Compressive Yield Strength, 1000 psi				
Artificially Aged	20, 40	18, 34	24, 24	17
Sol'n Treated & Aged	43, 36	—, 44	26, 27	—
Shear Strength, 1000 psi				
Artificially Aged	21, 30	21, 30	22, 24	28
Sol'n Treated & Aged	29, 36	24, 35	28, 34	—
THERMAL TREATMENT				
Annealing Temp, F	650	650	650	—
Solution Temp, F	950	960	980	—
Aging Temp, F	310	450	310	350
FABRICATING PROPERTIES				
Machinability[e]	AB	AB	B	A
Weldability[e, f]				
Gas	C, D	C, C	A, A	C
Arc	B, C	B, B	A, A	C
Resistance	B, B	B, B	A, A	C
CORROSION RESISTANCE	Good corrosion resistance; alloy 355 is superior. In general resistant to nitric, chromic and most organic acids; attacked by hydrochloric and sulfuric acids. Resistant to ammonium hydroxide; attacked by sodium, potassium and calcium hydroxides. Resistant to many salts, but attacked by salts of heavy metals. Resistant to attack by industrial and marine atmospheres			
AVAILABLE FORMS	Sand and permanent mold castings	Sand and permanent mold castings	Sand and permanent mold castings	Sand castings
USES	Sand—cylinder heads, bearing caps, bushings, tappet guides. Permanent mold—meter parts, automotive pistons, bushings, bearings	Sand—cylinder heads, diesel engine pistons	Sand—cylinder heads, water jackets, housings, printing press bed plates. Permanent mold—aircraft supercharger impellers, timing gears, meter parts, rotors	Stressed parts of aircraft, turret housings, air compressor pistons, instrument parts, machine parts

[d] High temperature resistant castings.
[e] A = excellent, AB = very good, B = good, C = fair, D = poor.
[f] The two values refer to sand and permanent mold castings, respectively.

continued on next page

Aluminum and Its Alloys—Cast

Type →	218	43	A13	A380
COMPOSITION, %	Mg 8.0, Al bal	Si 5.25, Al bal	Si 12.0, Fe 1.3 max Al bal	Cu 3.5, Si 8.5 Fe 1.3 max, Al bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.093	0.097	0.096	0.097
Solid. Temp Range, F	1150–995	1175–1070	1085–1065	1100–1000
Ther Cond (as cast, 68 F), Btu/hr/sq ft/°F/ft	56	84	70	58
Coef of Ther Exp (68–212 F), per °F	13.3×10^{-6}	12.2×10^{-6}	11.4×10^{-6}	11.7×10^{-6}
Elec Cond (as cast), % IACS	24	38	31	25
MECHANICAL PROPERTIES[d]				
Ten Str, 1000 psi	45	33	39	47
Yld Str (0.2% offset), 1000 psi	27	16	21	23
Elong (in 2 in.), %	8.0	9.0	2.0	4.0
Endurance Limit, 1000 psi	20	17	19	20
Compr Yld Str, 1000 psi	27	16	21	25
Shear Str, 1000 psi	29	21	25	30
FABRICATING PROPERTIES				
Machinability[e]	A	C	A	B
Weldability[e]				
Gas	D	B	D	D
Arc	D	B	D	D
Resistance	D	C	D	D
CORROSION RESISTANCE	Good corrosion resistance; alloys containing silicon are superior. In general: Resistant to nitric, chromic and most organic acids; attacked by hydrochloric and sulfuric acids. Resistant to ammonium hydroxide; attacked by sodium, potassium and calcium hydroxides. Resistant to many salts, but attacked by salts of heavy metals. Resistant to attack by industrial and marine atmospheres			
AVAILABLE FORMS	Die castings	Die castings	Die castings	Die castings
USES	Aircraft fittings and brake shoes, marine fittings, hardware	General purpose castings	Dental equipment, outboard motor pistons, typewriter frames	General purpose castings

[d] Die castings.
[e] A = excellent, AB = very good, B = good, C = fair, D = poor.

Aluminum and Its Alloys—Cast

Type →	319	C355	A356	327
COMPOSITION, %	Cu 3.8, Si 6.25, Al bal	Cu 1.25, Si 5.0, Mg 0.5, Al bal	Si 7.0, Mg 0.30, Al bal	Cu 1.5, Si 7.8, Mg 0.4, Mn 0.4, Al bal
PHYSICAL PROPERTIES				
Density, lb/cu in	0.100	0.097	0.097	0.096
Solid. Temp Range, F	1120–950	1150–1015	1135–1035	1110–1055
Ther Cond (as cast, 68 F), Btu/hr/sq ft/°F/ft	66	82[b]	92[b]	65
Coef of Ther Exp (68–212 F), per °F	12.0×10^{-6}	12.4×10^{-6}	11.9×10^{-6}	11.9×10^{-6}
Elec Cond (as cast), % IACS	28	37[b]	41[b]	29
MECHANICAL PROPERTIES[a]				
Tensile Strength, 1000 psi				
As Cast	27, 34	—	—	—, —
Solution Treated and Aged	36, 40	46	41	36, 49
Yld Str (0.2% offset), 1000 psi				
As Cast	18, 19	—	—	—, —
Solution Treated and Aged	24, 27	34	30	28, 40
Elongation (in 2 in.), %				
As Cast	2.0, 2.5	—	—	—, —
Solution Treated and Aged	2.0, 3.0	6.0	10.0	2.0, 3.0
Hardness, Brinell				
As Cast	70, 85	—	—	—, —
Solution Treated and Aged	80, 95	100	90	81, 97
Fatigue Str (5×10^8 cycles), 1000 psi				
As Cast	10, —	—	—	—, —
Solution Treated and Aged	11, —	14	13	—, —
Compr Yld Str (0.2% offset), 1000 psi				
As Cast	19, 19	—	—	—, —
Solution Treated and Aged	25, 27	36	32	20, —
Shear Str, 1000 psi[b]	29, —	32	28	—
THERMAL TREATMENT				
Annealing Temp, F	650	650	650	650
Solution Temp, F	940	980	1000	—
Aging Temp, F	310	310	310	—
FABRICATING PROPERTIES				
Machinability	Good	Good	Good	Good
Weldability (torch and arc)	Good	Good	Good	Good
CORROSION RESISTANCE	Fair	Good	Good	Good
AVAILABLE FORMS	Sand and permanent mold castings	Sand and permanent mold castings	Sand and permanent mold castings	Sand and permanent mold castings
USES	Engine parts, automotive cylinder heads, piano plates	Aircraft, missile and other structural uses requiring good strength		

[a] Where two values are given, they refer to sand and permanent mold castings, respectively. All single values are for permanent mold castings.
[b] Solution treated and aged.

Cobalt and Cobalt-Base Superalloys—Wrought

Type ➡	Cobalt[a]	S-816	V-36	Haynes Alloy 25, L-605[c]
COMPOSITION, %	Co 99.9	C 0.40, Mn 1.20, Cr 20.0, Ni 20.0, Mo 4.0, W 4.0, Cb 4.0, Fe 3.0, Co bal	C 0.32, Mn 1.0, Cr 25.0, Ni 20.0, Mo 4.0, Cb 2.3, Fe 2.4, Co bal	C 0.05–0.15, Mn 1.0–2.0, Cr 19.0–21.0, Ni 9.0–11.0, W 14.0–16.0, Fe 3.0, Si 1.0, Co bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.32	0.31	0.30	0.33
Melting Temp, F	2723	2350–2450	2350–2450	2425–2570
Ther Cond (1300 F), Btu/hr/sq ft/°F/ft	—	13.0	—	13.1
Coef of Ther Exp (70–1800 F), per °F	6.8×10^{-6}	9.3×10^{-6}	9.1×10^{-6}	9.4×10^{-6}
Spec Ht (77–1300 F), Btu/lb/°F	—	0.09	—	0.09 (80–212 F)
Elec Res, microhm-cm	—	93 (Aged)	—	188.7
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi				
Room Temp	30×10^6	35×10^6	32×10^6	34.2×10^6
1200 F	—	27.0×10^6	—	27.4×10^6
1500 F	—	25.4×10^6	—	26.3×10^6 (1400 F)
Ten Str, 1000 psi				
Room Temp	34.4	140	146	146
1500 F	—	73	61	47 (1600 F)
1800 F	—	26	28	34
2000 F	—	13	14	20
Yld Str (0.2% offset), 1000 psi				
Room Temp	20–43	70	83	67
1500 F	—	40	47	35 (1600 F)
1800 F	—	—	24	23
2000 F	—	—	13	12
Elongation (in 2 in.), %				
Room Temp	0.4	35	20	64
1500 F	—	22	18	30 (1600 F)
1800 F	—	20	11	41
2000 F	—	24	9	34
Fatigue Str (10^8 cycles), 1000 psi				
1200 F	—	38 (1500 F)	—	31 (1500 F)
1800 F	—	—	—	13
Rupture Str (1500 F), 1000 psi				
10 Hr	—	33	29	30
100 Hr	—	28	23	22
1000 Hr	—	21	18	18
THERMAL TREATMENT				
Solution Temp, F	—	2150 (1 hr, w.q.)	2250–2275 (1 hr, w.q.)	2250 (a.c.)
Aging Temp, F	—	1400 (12 hr, a.c.)	1400 (16 hr, a.c.)	—
FABRICATING PROPERTIES				
Hot Working Temp, F	930–1100	2250–1800	2250–1800	2250–1850
Machinability	Possible	9[b]	—	12[b]
Weldability	—	Good	Good	Good
CORROSION RESISTANCE	Excellent	Excellent	Excellent	Excellent
AVAILABLE FORMS	Rondelles, powders	Sheet, bar, billets, wire	Sheet, bar, billets, forgings, wire	Plate, sheet, bar, wire, tubing
USES	Alloy additions to steel cutting tools, magnets, etc.; also a coloring agent, drier and catalyst	High temperature applications requiring strength and corrosion resistance		

[a] All properties are of as-cast material. [b] Based on AISI B1112 steel = 100. [c] All properties are for solution heat treated 0.109-in. sheet.

Cobalt-Base Superalloys—Cast, Wrought

Type ➡	HS-21	HS-31, X-40	Nivco
COMPOSITION, %	C 0.20–0.30, Ni 1.75–3.75, Cr 25.5–29.0, Mo 5.0–6.0, Fe 2.0, Mn 1.0, Si 1.0, B 0.007, Co bal	C 0.45–0.55, Ni 9.5–11.5, Cr 24.5–26.5, Fe 2.0, Mn 1.0, Si 1.0, W 7.0–8.0, Co bal	C 0.02, Ni 22.5, Fe 0.3, Zr 1.10, Ti 1.80, Al 0.22, Mn 0.35, Si 0.15, Co bal
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.30	0.31	0.31
Melting Temp, F	2465	—	2550
Ther Cond (1100 F), Btu/hr/sq ft/°F/ft	11.9	12.8	16.6
Coef of Ther Exp (70–1500 F), per °F	8.7×10^{-6}	9.2×10^{-6}	8.1×10^{-6}
Elec Res (70 F), microhm-cm	87.4	97.0	23.7
MECHANICAL PROPERTIES[a]			
Mod of Elast in Tension, 10^6 psi			
Room Temp	36, —	29, 27	30
1200 F	—, 25	—, 24 (1350 F)	21
Ten Str, 1000 psi			
Room Temp	101, 125	108, 128	165
1000 F	74, 94	80, —	130
1200 F	71, 85	76, 76 (1350 F)	105
1600 F	55, 42	34 (1700 F), 49	—
Yld Str (0.2% offset), 1000 psi			
Room Temp	82, 110	76, 113	110
1000 F	39, 80	41, —	90
1200 F	—, 71	—, —	75
1600 F	—, 33	—, 36	—
Elongation (in 1 in.), %			
Room Temp	8.2, 1.7	9.0, 2.0	25
1000 F	19.6,[b] 1.3[b]	17.5, —	27
1200 F	16.0, 2.3[b]	12.0, —	20
1600 F	23.0, 19.3[b]	22 (1700 F), 14.3	—
Hardness (room temp), Rockwell	C30, C38	C34, C42[d]	C32–40
Impact Str (Charpy), ft-lb			
Room Temp	10, 4[c]	6, 4[c]	31
1500 F	27, 20[c]	16, 9[f]	—
Fatigue Str (10^8 cycles), 1000 psi			
Room Temp	35-40, —	—, —	52
1200 F	—, —	56, —	49
Rupture Str (1200 F), 1000 psi			
10 Hr	70, —	61, —	66
100 Hr	52, 22 (1500 F)[e]	56, 29 (1500 F)	54
1000 Hr	42, 14 (1500 F)[e]	51, 24 (1500 F)	43
THERMAL TREATMENT			
Solution Temp, F	—	—	1700–1750
Aging Temp, F	1350 (50 hr)	1350 (50 hr)	1150–1250
AVAILABLE FORMS	Investment castings	Investment castings	Bars, billets, strip, sheet, plate, wire, forgings
USES	Where resistance to thermal shock is required, especially in jet engines	Turbine blades and wheels and other parts subject to high temperatures	Where high damping capacity at high temperature is required, e.g., compression blades, tool supports, precipitron wires, etc.

[a] For HS-21 and HS-31 (X-40), the two values correspond to as-cast and as-cast and aged (50 hr at 1350 F); values for Nivco are for bar stock.
[b] In 2 in. [c] Aged 24 hr at 1350 F. [d] Aged 50 hr at 1475 F. [e] Aged 50 hr at 1500 F. [f] Aged 24 hr at 1500 F.

Coppers—Wrought

Type ➔	Electrolytic Tough Pitch Copper	Phosphorus Deoxidized Copper	Beryllium Copper	Oxygen-Free Copper	Chromium Copper
COMPOSITION, %	Cu 99.90 min, O about 0.04	Cu 99.90 min, P 0.015–0.040	Be 1.90–2.15, Co 0.20–0.35, Cu bal	Cu 99.92	Cu 99.05, Cr 0.85, Si 0.10
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.321–0.323	0.323	0.296–0.298	0.323	0.321
Melting Temp Range, F	1949–1981	1981	1600–1800	1981	2147
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	226	196	100–110[a]	226	187[a]
Coef of Ther Exp (68–572 F), per °F	9.8×10^{-6}	9.8×10^{-6}	9.3×10^{-6}	9.8×10^{-6}	9.8×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.092	0.092	0.10[b]	0.092	—
Elec Res (68 F, annealed), microhm-cm	1.71	2.03	4.82–5.82[a]	1.71	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	17×10^{6}	17×10^{6}	19×10^{6}	17×10^{6}	—
Ten Str, 1000 psi[c]					
Annealed	32, 35	32	60–80, 60–80[e]	32, 35	35, 63[j]
Hard	50, 55	50	165–185, 165–185[f]	50, 55	62, 70[j]
Yld Str, 1000 psi[c,d]					
Annealed	10	10	25–35, 20–30[e]	10	15, 45[j]
Hard	45	45	130–150, 150–170[f]	45	55, 60[j]
Elong (in 2 in.), %[c]					
Annealed	45, 35	45	35–50, 35–50[e]	45, 35	40, 25[j]
Hard	6, 1.5	10	3–12, 2–5[f]	6, 1.5	12, 20[j]
Hardness (Rockwell)					
Annealed	F40	F40	B50–65[e]	F40	F50, B65[j]
Hard	B50	B50	C36–41[f]	B50	B60, B84[j]
Shear Str, 1000 psi[c]					
Annealed	22, 24	22	50–60[e]	22, 24	—
Hard	28, 29	28	90–100[f]	28, 29	—
Endurance Limit (10^8 cycles), 1000 psi[c]					
Annealed	11	—	30–35, 12–20[e,g]	11	—
Hard	13	19	35–40, 120–140[f,g]	13	—
FABRICATING PROPERTIES					
Cold Workability	Excellent	Excellent	Good	Excellent	Good
Hot Workability	Excellent	Excellent	Excellent	Excellent	Good
Hot Working Temp, F	1400–1600	1400–1600	1050–1475	1400–1600	1650–1695
Annealing Temp, F	700–1200	700–1200	1400–1475	700–1200	—
Machinability Index[h]	20	20	20	20	20
Joining					
Soft Soldering	Excellent	Excellent	Excellent	Excellent	Excellent
Silver Alloy Brazing	Good	Excellent	Good	Excellent	Excellent
Oxyacetylene Welding	Poor	Good	Poor	Good	—
Carbon Arc Welding	Fair	Fair	Excellent	Good	—
Butt Resistance Welding	Good	Good	Excellent	Good	—
CORROSION RESISTANCE	Generally good resistance to industrial, rural and marine atmospheres; also gasolines, fuel oils and lacquers. Generally poor resistance to ammonia, ferric and ammonium compounds, and cyanides. Good resistance to weak acids and bases; some resistance to strong acids and bases				
AVAILABLE FORMS	Flat products, rod, wire, tube, pipe, shapes	Flat products, tube, pipe, rod, shapes	Flat products, rod, wire, tube, pipe, shapes		Flat products, wire, rod, shapes, simple forgings
USES	Architectural trim; automobile radiators; electrical contacts, conductors and switches; ball floats; rivets; chemical process equipment	Plumbing and gas lines; heat exchanger tubes; air, water, gasoline and oil lines; rotating bands	Instrument and valve springs, plunger guides, bushings, bearings, cams, diaphragms, bellows, electrical contacts, resistance welding electrodes	Bus bars and connectors, wave guides, copper-to-glass seals in electronic appliances	Resistance welding electrode tips and wheels, circuit breaker parts, cable connectors, parts for electronic devices

[a] Heat treated.
[b] 86–212 F.
[c] Where two values or ranges appear, second is for wire unless otherwise indicated.
[d] 0.5% extension under load except beryllium copper (0.2% offset).
[e] Solution annealed.
[f] Annealed and heat treated 2–3 hr at 600 F.
[g] Proportional limit.
[h] Based on free-cutting brass = 100.
[j] Heat treated rod: solution annealed ½ hr at 1830 F, quenched, precipitation heat treated 3 hr at 840 F.

Coppers and Plain Brasses—Wrought

Type ➡	Zirconium Copper	Sulfur Copper	Tellurium Copper	Gilding, 95%	Commercial Bronze, 90%
COMPOSITION, %	Zr 0.12, Cu bal	S 0.30, Cu bal	Te 0.50, Cu bal	Cu 95.0, Zn 5	Cu 90.0, Zn 0.0
PHYSICAL PROPERTIES					
Density, lb/cu in	0.323	0.323	0.323	0.320	0.318
Melting Temp Range, F	1976	1980	1980	1920–1950	1870–1910
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	—	216	209	135	109
Coef of Ther Exp (68–572 F), per °F	—	9.8×10^{-6}	9.8×10^{-6}	10.0×10^{-6}	10.2×10^{-6}
Spec Ht (68 F), Btu/lb/°F	—	0.09	0.09	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	1.99	1.78	1.91	3.1	3.9
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	—	—	16×10^6	17×10^6	17×10^6
Ten Str, 1000 psi					
Annealed	—	34	—	34	37
Hard	56–80[b]	50[c]	48[c]	56	61
Yld Str (0.5% ext), 1000 psi					
Annealed	—	10	—	10	10
Hard	48–75[b]	48[c]	44[c]	50	54
Elong (in 2 in.), %					
Annealed	—	42	—	45	45
Hard	25–5[b]	12[c]	12[c]	5	5
Hardness (Rockwell)					
Annealed	—	—	—	F46	F53
Hard	B69–75[b]	B45[c]	B45[c]	B64	B70
Shear Str, 1000 psi					
Annealed	—	—	—	26	28
Hard	—	—	—	37	38
FABRICATING PROPERTIES					
Cold Workability	Excellent	Excellent	Good	Excellent	Excellent
Hot Workability	—	Excellent	Good	Good	Good
Hot Working Temp, F	—	1400–1600	1400–1550	1400–1600	1400–1600
Annealing Temp, F	—	800–1200	800–1200	800–1450	800–1450
Machinability Index[a]	20	90	90	20	20
Joining					
Soft Soldering	—	Excellent	Good	Excellent	Excellent
Silver Alloy Brazing	—	Excellent	Good	Excellent	Excellent
Oxyacetylene Welding	—	Fair	Fair	Good	Good
Carbon Arc Welding	—	Fair	Fair	Fair	Fair
Butt Resistance Welding	—	Good	Good	Good	Good
CORROSION RESISTANCE	Generally good resistance to industrial, rural and marine atmospheres; also gasolines, fuel oils and lacquers. Generally poor resistance to ammonia, ferric and ammonium compounds, and cyanides. Good resistance to weak acids and bases; some resistance to strong acids and bases				
AVAILABLE FORMS	Rod, wire	Rod	Rod	Rolled strip, wire	Rolled strip, sheet, wire, tube, plate, rod
USES	Commutator segments, slip rings, soldering iron tips, rectifier bases, resistance welding wheel electrodes, orifice for reaction motors	Electric and electronic parts, welding torch tips, soldering tips, screw machine parts requiring high conductivity	Torch tips, soldering iron tips, electrical connectors, screw machine products requiring high conductivity	Coins, bullet jackets, fuse caps, primers, jewelry, base for gold plate or vitreous enamel	Grillwork, cosmetic compacts, marine hardware, primer caps, costume jewelry, base for vitreous enamel

[a] Based on free-cutting brass = 100. [b] Range covers properties obtainable by varying amounts of cold work. [c] Half-hard.

continued on next page

Plain Brasses—Wrought

Type ➔	Red Brass, 85%	Low Brass, 80%	Cartridge Brass, 70%	Yellow Brass	Muntz Metal
COMPOSITION, %	Cu 85, Zn 15	Cu 80, Zn 20	Cu 70, Zn 30	Cu 65, Zn 35	Cu 60, Zn 40
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.316	0.313	0.308	0.306	0.303
Melting Temp Range, F	1810–1880	1770–1830	1680–1750	1660–1710	1650–1660
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	92	81	70	67	71
Coef of Ther Exp (68–572 F), per °F	10.4×10^{-6}	10.6×10^{-6}	11.1×10^{-6}	11.3×10^{-6}	11.6×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.09	0.09	0.09	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	4.7	5.4	6.2	6.4	6.2
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	17×10^6	16×10^6	16×10^6	15×10^6	15×10^6
Ten Str, 1000 psi[c]					
Annealed	39, 41	42, 44	44, 48	46, 50	54
Hard	70, 88	74, 107	76	74, 110	—
Yld Str, 1000 psi[c,d]					
Annealed	10	12	11	14	21
Hard	57	59	63	60	—
Elong (in 2 in.), %[c]					
Annealed	48, 48	52, 55	66, 64	65, 60	45
Hard	5, 6	7, 5	8	8, 8	—
Hardness (Rockwell)					
Annealed	F56	F57	F54	F58	F80
Hard	B77	B82	B82	B80	—
Shear Str, 1000 psi[c]					
Annealed	31, 31	32, 32	—	32, 34	40
Hard	42, 48	43, 53	44	43, 55	—
Endur Limit (10^8 cycles), 1000 psi[c]					
Annealed	10.5	14	13	12	—
Hard	21, 29	22, 23	21	14	—
FABRICATING PROPERTIES					
Cold Workability	Excellent	Excellent	Excellent	Excellent	Fair
Hot Workability	Good	Fair	Fair	Poor	Excellent
Hot Working Temp, F	1450–1650	1500–1650	1350–1550	—	1150–1450
Annealing Temp, F	800–1350	800–1300	800–1400	800–1300	800–1100
Machinability Index[j]	30	30	30	30	40
Joining					
Soft Soldering	Excellent	Excellent	Excellent	Excellent	Excellent
Silver Alloy Brazing	Excellent	Excellent	Excellent	Excellent	Excellent
Oxyacetylene Welding	Good	Good	Good	Good	Good
Butt Resistance Welding	Good	Good	Good	Good	Good
CORROSION RESISTANCE	Generally good resistance to industrial, rural and marine atmospheres; also gasolines, fuel oils and lacquers. Generally poor resistance to ammonia, ferric and ammonium compounds, and cyanides				
	Good res to weak acids and bases; some res to strong acids and bases. Highly res to dezincification or stress-corrosion cracking	Susceptible to dezincification and stress corrosion cracking			
		Good res to weak bases; some res to strong bases and weak acids; poor res to strong acids	Some resistance to weak acids and bases; poor resistance to strong acids and bases. Good resistance to sulfides. Poor resistance to soft and high salinity water		
AVAILABLE FORMS	Rolled strip, sheet, wire, tube, pipe	Wire, rolled strip and flat wire	Rolled strip and bar, flat wire, sheet, rod, wire, tube	Rolled strip and flat wire, drawn flat wire, sheet, plate, rod, wire	Rolled strip and bar, sheet, plate, rod, tube
USES	Weatherstrip, electrical sockets, fasteners, heat exchanger tubes, flexible hose, plumbing, jewelry	Ornamental metal work, battery caps, musical instruments, clock dials, pump lines	Automotive radiator cores and tanks, lamp fixtures, fasteners, springs, ammunition components	Grillwork, reflectors, lamp fixtures, fasteners, stencils, plumbing accessories, springs	Architectural trim, large nuts and bolts, condenser plates, hot forgings, valve stems

[c]Where two values appear, second is for wire. [d]0.5% extension under load. [j]Based on free-cutting brass = 100.

Tin and Aluminum Brasses—Wrought

Type ➡	Admiralty	Naval Brass	Leaded Naval Brass	Manganese Bronze (A)	Aluminum Brass
COMPOSITION, %	Cu 71, Sn 1, Zn 28	Cu 60, Sn 0.75, Zn 39.25	Cu 60, Pb 1.75, Sn 0.75, Zn 37.5	Cu 58.5, Fe 1.4, Sn 1, Mn 0.1, Zn 39	Cu 76, Al 2, Zn 22
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.308	0.304	0.305	0.302	0.301
Melting Temp Range, F	1650–1720	1630–1650	1630–1650	1590–1630	1710–1780
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	64	67	67	61	58
Coef of Ther Exp (68–572 F), per °F	11.2×10^{-6}	11.8×10^{-6}	11.8×10^{-6}	11.8×10^{-6}	10.3×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.09	0.09	0.09	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	6.9	6.6	6.6	7.2	7.5
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension, psi	16×10^6	15×10^6	15×10^6	15×10^6	16×10^6
Ten Str, 1000 psi					
Annealed[b]	53	57	57	65	60
Quarter Hard	—	69	69	77	—
Half Hard	—	75	75	84	—
Yld Str, 1000 psi[b]					
Annealed	22	25	25	30	27
Quarter Hard	—	46	46	45	—
Half Hard	—	53	53	60	—
Elong (in 2 in.), %					
Annealed	65	47	40	33	55
Quarter Hard	—	27	20	23	—
Half Hard	—	20	15	19	—
Hardness (Rockwell)					
Annealed	F75	B55	B55	B65	F77
Quarter Hard	—	B78	B78	B83	—
Half Hard	—	B82	B82	B90	—
Shear Str, 1000 psi					
Annealed	—	40	36	42	—
Quarter Hard	—	43	39	47	—
Half Hard	—	44	40	48	—
FABRICATING PROPERTIES					
Cold Workability	Excellent	Fair	Poor	Poor	Excellent
Hot Workability	Fair	Excellent	Good	Excellent	Fair
Annealing Temp, F	800–1100	800–1100	800–1100	800–1100	800–1100
Machinability Index[c]	30	30	70	30	30
Joining					
Soft Soldering	Excellent	Excellent	Excellent	Excellent	Fair
Silver Alloy Brazing	Excellent	Excellent	Good	Excellent	Good
Oxyacetylene Welding	Fair	Good	Fair	Good	Fair
Butt Resistance Welding	Good	Good	Fair	Good	Good
CORROSION RESISTANCE	Good resistance to industrial, rural and marine atmospheres; petroleum products, alcohols, dry gases and sea water. Fairly good resistance to weak bases. Resistance to some weak bases and weak organic acids, but generally poor resistance to most acids and strong bases. Poor resistance to solutions of cyanides and ammonium compounds. Resistant to dezincification (especially Admiralty and Aluminum Brasses)				
AVAILABLE FORMS	Plate, wire, tube	Rolled strip, rolled and drawn bar, plate, rod, tube, shapes	Drawn bar, rod, shapes	Rod, shapes	Tube
USES	Condenser, evaporator and heat exchanger tubes; condenser tube plates; distiller tubes; ferrules	Aircraft turnbuckle barrels, balls, bolts, marine hardware, nuts propeller shafts, rivets, valve stems, condenser plates, welding rods	Marine hardware, screw machine products, valve stems	Clutch disks, pump rods, shafting, balls, valve stems and bodies, welding rods	Condenser, evaporator and heat exchanger tubes, distiller tubes, ferrules

[a] Mechanical properties are based on 1-in. dia. Values for Admiralty and Aluminum Brasses apply to tube; other values apply to rod.
[b] 0.5% extension under load. [c] Based on free-cutting brass = 100.

Leaded Brasses—Wrought

Type ➡	Leaded Commercial Bronze	Low-Leaded Brass	Medium-Leaded Brass	High-Leaded Brass	Extra-High-Leaded Brass
COMPOSITION, %	Cu 89.0, Pb 1.75, Zn 9.25	Cu 65.0, Pb 0.5, Zn 34.5	Cu 65.0, Pb 1.0, Zn 34.0	Cu 65.0, Pb 2.0, Zn 33.0	Cu 63.0, Pb 2.5, Zn 34.5
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.319	0.306	0.306	0.306	0.307
Melting Temp Range, F	1850–1900	1650–1700	1630–1700	1630–1670	1630–1660
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	104	67	67	67	67
Coef of Ther Exp (68–572 F), per °F	10.2×10^{-6}	11.3×10^{-6}	11.3×10^{-6}	11.3×10^{-6}	11.4×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.09	0.09	0.09	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	4.1	6.6	6.6	6.6	6.6
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	17×10^6	15×10^6	15×10^6	15×10^6	14×10^6
Ten Str, 1000 psi					
Annealed	—	51	51	49	49
Hard	55[b]	74	74	74	74
Yld Str (0.5% ext), 1000 psi					
Annealed	—	19	19	17	17
Hard	50[b]	60	60	60	60
Elong (in 2 in.), %					
Annealed	—	55	53	52	50
Hard	12[b]	8	7	7	7
Hardness (Rockwell)					
Annealed	—	F72	F72	F68	F68
Hard	B61[b]	B80	B80	B80	B80
Shear Str, 1000 psi					
Annealed	—	34	34	34	—
Hard	31[b]	43	43	43	—
FABRICATING PROPERTIES					
Cold Workability	Good	Good	Good	Fair	Poor
Hot Workability	Poor	Poor	Poor	Poor	Fair
Hot Working Temp, F	—	—	—	—	1300–1450
Annealing Temp, F	800–1200	800–1300	800–1200	800–1100	800–1100
Machinability Index[a]	80	60	70	90	100
Joining					
Soft Soldering	Excellent	Excellent	Excellent	Excellent	Excellent
Silver Alloy Brazing	Good	Good	Good	Good	Good
Oxyacetylene Welding	Not Rec	Fair	Not Rec	Not Rec	Not Rec
Butt Resistance Welding	Good	Good	Good	Good	Good
CORROSION RESISTANCE	Excellent resistance to pure hydrocarbons, lacquers and freon; good resistance to industrial, marine and rural atmospheres, alcohols, fuel oils and dry carbon dioxide; fair resistance to sea water, crude oils, and moist carbon dioxide; attacked by ammonium hydroxide and hydrochloric and sulfuric acids				
AVAILABLE FORMS	Bar, rod	Strip, bar, plate[c]	Strip, bar, plate, rod, wire	Strip, bar, plate, rod[d]	Strip, bar, plate, rod
USES	Screws, screw machine parts, pickling crates	Butts, hinge brass, watch backs	Butts, gears, nuts, rivets, screws, dials, engravings, instrument plates	Clock plates, nuts, backs, gears, wheels	

[a] Based on free-cutting brass = 100.
[b] Half-hard.
[c] Low-leaded brass tube is also available which has approximately the same properties and is used for plumbing accessories and pumps.
[d] High-leaded brass tube is also available with approximately the same properties and is used for general purpose screw machine parts.

Leaded Brasses—Wrought

Type →	Free-Cutting Brass	Leaded Muntz Metal	Free-Cutting Muntz Metal	Forging Brass	Architectural Bronze
COMPOSITION, %	Cu 61.5, Pb 3.0, Zn 35.5	Cu 60.0, Pb 0.6, Zn 39.4	Cu 60.0, Pb 1.0, Zn 39.0	Cu 59.0, Pb 2.0, Zn 39.0	Cu 57.0, Pb 3.0, Zn 40.0
PHYSICAL PROPERTIES					
Density, lb/cu in	0.307	0.304	0.304	0.305	0.306
Melting Temp Range, F	1630–1650	1630–1650	1630–1650	1620–1640	1610–1630
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	67	71	69	69	71
Coef of Ther Exp (68–572 F), per °F	11.4×10^{-6}	11.6×10^{-6}	11.6×10^{-6}	11.5×10^{-6}	11.6×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.09	0.09	0.09	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	6.6	6.2	6.4	6.4	6.2
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	14×10^6	15×10^6	15×10^6	15×10^6	14×10^6
Ten Str, 1000 psi					
Annealed	49	54[c]	54	52[d]	60[d]
Hard	68[b]	—	80	—	—
Yld Str (0.5% ext), 1000 psi					
Annealed	18	20[c]	20	20[d]	20[d]
Hard	52[b]	—	60	—	—
Elong (in 2 in.), %					
Annealed	53	45[c]	40	45[d]	30[d]
Hard	18[b]	—	6	—	—
Hardness (Rockwell)					
Annealed	F68	F80[c]	F80	F78[d]	B65[d]
Hard	B80[b]	—	B85	—	—
Shear Str, 1000 psi					
Annealed	30	40[c]	—	—	35[d]
Hard	38[b]	—	—	—	—
FABRICATING PROPERTIES					
Cold Workability	Poor	Fair	Fair	Poor	Poor
Hot Workability	Fair	Excellent	Excellent	Excellent	Excellent
Hot Working Temp, F	1300–1450	1150–1450	1150–1450	1200–1500	1150–1350
Annealing Temp, F	800–1100	800–1100	800–1100	800–1100	800–1100
Machinability Index[a]	100	60	70	80	90
Joining					
Soft Soldering	Excellent	Excellent	Excellent	Excellent	Excellent
Silver Alloy Brazing	Good	Good	Good	Good	Good
Oxyacetylene Welding	Not Rec	Fair	Not Rec	Not Rec	Not Rec
Butt Resistance Welding	Good	Good	Good	Good	Good
CORROSION RESISTANCE	Excellent resistance to pure hydrocarbons, fluorinated hydrocarbon refrigerants and lacquers; good resistance to industrial, marine and rural atmospheres, alcohols, fuel oils and dry carbon dioxide; fair resistance to sea water, crude oils, and moist carbon dioxide; attacked by ammonium hydroxide and hydrochloric and sulfuric acids				
AVAILABLE FORMS	Bar, rod, shapes	Plate	Tube	Rod, shapes	Rod, shapes
USES	Gears, pinions, high speed screw machine parts	Condenser tube plates	Automatic screw machine parts	Forgings and pressings of all kinds	Architectural extrusions, store fronts, trim, hinges, lock bodies, forgings

[a] Based on free-cutting brass = 100. [b] Half-hard. [c] As hot rolled. [d] As extruded.

Phosphor Bronzes—Wrought

Type ➡	Phosphor Bronze, 5% (Grade A)	Phosphor Bronze, 8% (Grade C)	Phosphor Bronze, 10% (Grade D)	Phosphor Bronze, 1.25% (Grade E)	Phosphor Bronze (Free-Cutting)
COMPOSITION, %	Cu 95, Sn 5	Cu 92, Sn 8	Cu 90, Sn 10	Cu 98.75, Sn 1.25, P trace	Cu 88, Pb 4, Zn 4, Sn 4
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.320	0.318	0.317	0.321	0.321
Melting Temp Range, F	1750–1920	1620–1880	1550–1830	1900–1970	1700–1830
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	40	36	29	120	50
Coef of Ther Exp (68–572 F), per °F	9.9×10^{-6}	10.1×10^{-6}	10.2×10^{-6}	9.9×10^{-6}	9.6×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.09	0.09	0.09	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	9.6	13	16	3.6	9.1
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	16×10^6	16×10^6	16×10^6	17×10^6	15×10^6
Ten Str, 1000 psi[a]					
Annealed	47, 50	55, 60	66, 66	40, —	44, —
Half Hard	68, 85	76, 105	83, 118	55, —	58, —
Hard	81, 110	93, 130	100, 147	65, 76	—
Spring	100, 140	112, —	122, —	75, —	—
Extra Spring	107, —	120, —	128, —	—, —	—
Yld Str, 1000 psi[b]					
Annealed	19, 20	24	28	14	19
Half Hard	55, 80	55	—	—	40
Hard	75	72	—	50	—
Elong (in 2 in.), %					
Annealed	64 58	70, 65	68	48	50
Half Hard	28, 8	32	32	16	24
Hard	10	10	13	8	—
Spring	4	3	4	4	—
Extra Spring	3	2	3	—	—
Hardness (Rockwell)					
Annealed	B26	F75	B55	—	F65
Half Hard	B78	B84	B92	B64	B68
Hard	B87	B93	B97	B75	—
Spring	B95	B98	B101	B79	—
Extra Spring	B97	B100	B103	—	—
FABRICATING PROPERTIES					
Cold Workability	Excellent	Good	Good	Excellent	Good
Hot Workability	Poor	Poor	Poor	Good (1450–1600 F)	—
Annealing Temp F	900–1250	900–1250	900–1250	900–1200	900–1250
Machinability Index[c]	20	20	20	20	80
Joining					
Soft Soldering	Excellent	Excellent	Excellent	Excellent	Excellent
Silver Alloy Brazing	Excellent	Excellent	Good	Excellent	Excellent
Oxyacetylene Welding	Fair	Fair	Good	Good	Not rec
Butt Resistance Welding	Excellent	Excellent	Excellent	Excellent	Good
CORROSION RESISTANCE	Generally good resistance to atmosphere, water and salt water, and salt solutions. Some resistance to alkaline solutions and inorganic acids. Poor resistance to organic acids, cyanides, and ferric and ammonium compounds				
AVAILABLE FORMS	Rolled strip, rolled flat wire, rod, wire, tube	Rolled strip, rod, wire		Rolled strip, wire	Rolled strip, rod, shapes
USES	Bridge bearing plates, chemical hardware, perforated sheets, textile machinery, welding rods, beater bars, bellows, clutch disks, cotter pins, diaphragms, fuse clips, fasteners, lock washers, sleeve bushings, springs, switch parts, truss wire, wire brushes		Heavy bars and plates for severe compression, good wear and corrosion resistance. Bridge and expansion plates	Electrical contacts, flexible hose, pole-line hardware	Bearings, bushings, gears, pinions, shafts, thrust washers, valve parts

[a] Two values are for flat products and wire, respectively. [b] 0.5% extension under load. [c] Based on free-cutting brass = 100.

Silicon Bronzes—Wrought

Type ➡	High Silicon Bronze (A)	Low Silicon Bronze (B)	Aluminum Silicon Bronze	Precipitation Hardenable Silicon Bronze [a]
COMPOSITION, %	Cu 94.8 min, Si 2.8–3.8, Mn 1.5 max, Zn 1.5 max, Fe 1.6 max, Ni 0.6 max	Cu 96.0 min, Si 0.8–2.0[e], Mn 0.7 max, Fe 0.8 max	Cu 89.0 min, Al 6.5–8.0, Si 1.5–3.0	Cu 97.5, Ni 1.9, Si 0.6
PHYSICAL PROPERTIES				
Density, lb/cu in	0.308	0.316	0.278	0.322
Melting Temp Range, F	1880–1780	1940–1890	1840[f]	1990[f]
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	20	31	26	—
Coef of Ther Exp (68–572 F), per °F	10.0×10^{-6}	9.9×10^{-6}	10.0×10^{-6}	9.8×10^{-6}
Specific Heat, Btu/lb/F	0.09	0.09	0.09	—
Elec Cond, % IACS	7	12	7	36[h]
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	15×10^{6}	17×10^{6}	16×10^{6}	18×10^{6}
Ten Str, 1000 psi				
Annealed Strip, Rod[b]	56–63	40[d]	85–90[d]	65[d]
Hardened Rod	92	70	90	100
Yield Strength (0.5% ext), 1000 psi				
Annealed Strip, Rod[b]	20–30	15[d]	44–60[d]	60[d]
Hardened Rod	55	55	50	88[d]
Elongation (in 2 in.), %				
Annealed Strip, Rod[b]	55–63	50[d]	20–30[d]	20[i]
Hardened Rod	22	15	40	22[d]
Hardness (Rockwell)				
Annealed Strip, Rod[b]	B35–66	F55–60	B74–90[d]	—
Hardened Rod	B90	B80	B92	B90[d]
Impact Strength (Izod, annealed strip, rod), ft-lb[b]	60–70[d]	60–70[d]	17[d]	—
Shear Strength (annealed strip, rod), 1000 psi[b]	42–45	—	45[d]	—
FABRICATING PROPERTIES				
Cold Workability	Excellent	Excellent	Poor	Excellent
Hot Workability	Excellent	Excellent	Excellent	Excellent
Hot Working Temp Range, F	1300–1600	1300–1600	1300–1600	1300–1700
Annealing Temp, F	900–1300	900–1250	1100–1125	850–1450
Machinability Index[c]	30	30	60	40
Joining				
Soft Soldering	Good	Good	Not recommended[g]	Excellent
Silver Alloy Brazing	Excellent	Excellent	Fair	Excellent
Oxyacetylene Welding	Excellent	Excellent	Poor	Excellent
Carbon Arc Welding	Excellent	Excellent	Fair	Excellent
Gas Shielded Arc Welding	Excellent	Excellent	Fair	Excellent
Resistance Welding	Excellent	Good	Fair	Excellent
CORROSION RESISTANCE	Excellent resistance to marine, industrial and rural atmospheres; most types of fresh and sea water; hot and cold dilute sulfuric, cold concentrated sulfuric, cold dilute hydrochloric, and most organic acids; hot and cold dilute alkalis and cold concentrated alkalis; chlorides and sulfates of light metals. Attacked by oxidizing acids and ammonium hydroxide; poor resistance to chlorides and sulfates of heavy metals			
AVAILABLE FORMS	Sheet, strip, plate, rod, wire, pipe, tube		Forgings, pressings	Rod, wire, sheet
USES	Welded unfired hot water storage heaters, heat exchangers, signs, hot headed fasteners, cast fittings, seamless tube or pipe, clutch disks	Cold headed cap and machine screws, wire and cable connectors, pole line hardware, marine hardware, valve components, tubing	Hot forged or pressed valve components, welding equipment, aircraft compression fittings, gears and pinions, large nuts and bolts	High strength mechanical fasteners; electrical, marine and chemical processing hardware. Sheet used for springs, sockets, etc. requiring high strength

[a] Properties of hardened material obtained by precipitation hardening 90 min at 700-850 F.
[b] Varies with grain size.
[c] Based on free-cutting brass = 100.
[d] Rod only.
[e] An alloy containing up to 2.6% Si is acceptable if the sum of all elements excepting Cu and Si is less than 0.3%.
[f] Solidus temperature not available.
[g] Can be soldered with special techniques.
[h] In fully heat treated condition.
[i] Elongation in 4D.

Nickel Silvers—Wrought

Type →	65-18	65-12	65-15	65-10	55-18
COMPOSITION, %	Cu 65, Ni 18, Zn 17	Cu 65, Ni 12, Zn 23	Cu 65, Ni 15, Zn 20	Cu 65, Ni 10, Zn 25	Cu 55, Ni 18, Zn 27
PHYSICAL PROPERTIES					
Density (68 F), lb/cu in.	0.316	0.314	0.314	0.313	0.314
Melting Temp Range, F	1960–2030	1900	1970	1870	1930
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	19	23	21	26	17
Coef of Ther Exp (68–572 F), per °F	9.0×10^{-6}	9.0×10^{-6}	9.0×10^{-6}	9.1×10^{-6}	9.3×10^{-6}
Spec Ht (68 F) Btu/lb/°F	0.09	0.09	0 09	0.09	0.09
Elec Cond (68 F), % IACS	6	8	7	9	5.5
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	18×10^6	18×10^6	18×10^6	17.5×10^6	18×10^6
Ten Str, 1000 psi					
Annealed	56–60	52–61	53–61	49–63	60
Half Hard	70–86	73	74	73–85	—
Hard	85–103	85	85	86–105	100
Extra Hard	—	93	92	95–120	108
Yld Str, 1000 psi[a]					
Annealed	25–30	18–28	18–28	18–28	27
Half Hard	60–80	60	62	60	—
Hard	74–90	75	75	75	85
Extra Hard	—	79	79	76	90
Elong (in 2 in.), %					
Annealed	32–45	35–48	34–43	35–50	40
Half Hard	7–20	11	10	7–12	—
Hard	3	4	3	4–5	3
Extra Hard	—	2	2	3	2 5
Hardness (Rockwell)					
Annealed	B40–55	B22–55	B22–55	B22–52	B55
Half Hard	B78–83	B80	B80	B80	—
Hard	B87	B89	B87	B89	B91
Extra Hard	—	B92	B90	B92	B96
Shear Str, 1000 psi					
Annealed	—	41	41	41	—
Half Hard	—	47	47	50	—
Hard	—	52	52	55	—
Extra Hard	—	56	54	59	—
FABRICATING PROPERTIES					
Cold Workability	Excellent	Excellent	Excellent	Excellent	Good
Hot Workability	Poor	Poor	Poor	Poor	Poor
Annealing Temp, F	1100–1500	1100–1500	1100–1500	1100–1400	1100–1500
Machinability Index[b]	20	20	20	20	30
Joining	Soldering, excellent; silver alloy brazing, excellent; carbon arc welding, fair; butt resistance welding, good; oxy-acetylene welding, good				
CORROSION RESISTANCE	Attacked rapidly by oxidizing acids. Resistant to sodium and potassium hydroxide but attacked rapidly by ammonium hydroxide and moist ammonia. Good resistance to rural and marine atmospheres and to fresh and salt waters Subject to stress corrosion				
AVAILABLE FORMS	Sheet; strip; rods, bars, and shapes; wire; spring. Forging, extruding and casting alloys are also available				
USES	Most popular. Hardware, marine and automotive trim, camera parts, lighting fixtures, costume jewelry, screws, springs, slide fasteners	Slide fasteners, nameplates, decorative trim, camera parts	Optical equipment, etching stock, jewelry	Rivets, screws, slide fasteners, optical parts, hollow ware, nameplates	Excellent for springs. Springs and contacts in telephone equipment, electrical controls. Resistance wire, surgical and dental instruments, diaphragms; hardware

[a] 0.5% extension under load. [b] Based on free-cutting brass = 100.

Cupro-Nickels—Wrought

Type ➜	Cupro-Nickel, 30%	Cupro-Nickel, 20%	Cupro-Nickel, 10%
COMPOSITION, %	Cu 68.9, Ni 30, Fe 0.5, Mn 0.6	Cu bal, Ni 21, Fe 0.5, Mn 0.6	Cu 88.35, Ni 10, Fe 1.25, Mn 0.4
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.323	0.323	0.323
Melting Temp Range, F	2260–2140	2190–2100	2080–2020
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	17	21	26
Coef of Ther Exp (68–572 F), per °F	9.0×10^{-6}	9.1×10^{-6}	9.3×10^{-6}
Specific Heat, Btu/lb/°F	0.09	0.09	0.09
Electrical Resistivity (68 F), microhm-cm	37	27	15
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	22×10^6	20×10^6	18×10^6
Tensile Strength, 1000 psi			
Annealed[a]	54–60	45–51	44
Half Hard[b]	73	—	—
Hard[b]	80	—	—
Light Drawn[c]	75	80	60
Yield Strength (0.5% ext), 1000 psi			
Annealed[a]	20–22	—	15
Half Hard[b]	68	—	—
Hard[b]	73	—	—
Light Drawn[c]	—	75	57
Elongation (in 2 in.), %			
Annealed[a]	40–45	27	40
Half Hard[b]	12	—	—
Hard[b]	6	—	—
Light Drawn[c]	45	40	42
Hardness (Rockwell)			
Annealed[a]	B37–50	—	B10
Half Hard[b]	B80	—	—
Hard[b]	B85	—	—
Light Drawn[c]	B85	B81	B72
Creep Strength (0.001%/1000 hr), 1000 psi			
At 300 F	24	>25	>30
At 500 F	16	17	11
FABRICATING PROPERTIES			
Cold Workability	Good	Good	Good
Hot Workability	Good	Good	Good
Hot Working Temp, F	1700–1900	1650–1850	1550–1750
Annealing Temp, F	1200–1500	1200–1500	1100–1500
Machinability Index[d]	20	20	20
Joining			
Soft Soldering	Excellent	Excellent	Excellent
Silver Alloy Brazing	Excellent	Excellent	Excellent
Metal Arc Welding	Excellent	Excellent	Good
Gas Shielded Arc Welding	Excellent	Excellent	Excellent
Resistance Welding	Excellent	Excellent	Good
Oxyacetylene Welding	Fair	Fair	Fair
Carbon Arc Welding	Not recommended	Not recommended	Not recommended
CORROSION RESISTANCE	Resistant to attack by high velocity sea water, fresh water, steam; sulfuric, phosphoric and mild organic acids; ammonia and ammoniacal compounds, chlorides, sulfates, nitrates		
AVAILABLE FORMS	Plate, rod, strip, tube, wire		
USES	Condenser tubes and plates, heat exchanger tubes, salt water piping, evaporator tubes, process equipment, distillation tubes. ASME code permits use of Cupro-Nickel, 30% in heat exchangers and unfired pressure vessels up to 700 F		

[a] Properties of annealed materials vary with grain size. [b] Strip. [c] Tube. [d] Based on free-cutting brass –100.

Leaded Brasses and Bronzes—Cast

BBII Grade →	Leaded Tin Bronzes[a]		
	2A	2B	2C
COMPOSITION, %	Cu 88, Sn 6, Pb 1.5, Zn 4.5	Cu 87, Sn 8, Pb 1, Zn 4	Cu 87, Sn 8, Pb 1, Zn 2
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.311–0.318	0.314–0.320	0.314–0.320
Melting Temp Range, F	1830	1830–1570	1830–1570
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	—	28	28
Coef of Ther Exp (70–350 F), per °F	10.3×10^{-6}	10×10^{-6}	10×10^{-6}
Electrical Conductivity (68 F), % IACS	14	11	11
MECHANICAL PROPERTIES[b]			
Mod of Elast in Tension, psi	$12\text{–}16 \times 10^{6}$	$10.6\text{–}16 \times 10^{6}$	$10.6\text{–}16 \times 10^{6}$
Tensile Strength, 1000 psi	36–48	33–43	36–46
Yield Strength (0.5% ext), 1000 psi	16–21	16–24	18–26
Elongation (in 2 in.), %	25–40	18–30	15–25
Reduction of Area, %	16–33	15–30	12–26
Hardness (Brinell)	60–72	60–75	65–80
Impact Strength (Izod), ft-lb	11–16	12–15	7–10
Compr Yld Str (0.001-in. set), 1000 psi	12–15	9–11	12–14
FABRICATING PROPERTIES			
Casting Temp Range, F			
Light Castings	2000–2300	2100–2300	1200–2300
Heavy Castings	1900–2150	1920–2100	1920–2100
USES	Oil pumps, gears, bushings, high duty bearings, ornamental bronze	General utility structural bronze, pipe fittings, expansion joints, pressure valves	Bolts, nuts, gears, valves, pump pistons, pressure pipe fittings, expansion joints

BBII Grade →	High-Leaded Tin Bronzes[a]			
	3A	3B	3D	3E
COMPOSITION, %	Cu 80, Sn 10, Pb 10	Cu 83, Sn 7, Pb 7, Zn 3	Cu 78, Sn 7, Pb 15	Cu 71, Sn 5, Pb 24
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.321–0.328	0.320–0.322	0.329–0.340	0.332–0.343
Melting Temp (approx), F	1770	1800	1750	1700
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	27	—	—	—
Coef of Ther Exp (70–400 F), per °F	10.2×10^{-6}	10×10^{-6}	10.3×10^{-6}	—
MECHANICAL PROPERTIES[b]				
Mod of Elast in Tension	$8.5\text{–}13 \times 10^{6}$	—	$8.8\text{–}12.6 \times 10^{6}$	$9\text{–}12 \times 10^{6}$
Tensile Strength, 1000 psi	27–37	30–38	25–33	23–30
Yield Strength (0.5% ext), 1000 psi	15–22	17–21	14–20	11–15
Elongation (in 2 in.), %	8–12	12–20	10–18	7–16
Reduction of Area, %	5–11	10–22	8–15	5–12
Hardness (Brinell)	55–70	55–65	50–60	42–35
Impact Strength (Izod), ft-lb	2–8	—	4–6	4–6
Compr Yld Str (0.001-in. set), 1000 psi	12.5–16	—	13–16	12–14
FABRICATING PROPERTIES				
Casting Temp Range, F				
Light Castings	2000–2250	2000–2250	2000–2250	2000–2200
Heavy Castings	1850–2100	1900–2050	1900–2100	1850–2000
USES	General purpose bushing and bearing alloy	General purpose bearing alloy, bushings, automobile fittings	Bearing bronze for moderate pressure, mine water pump parts	Bearings operating at high speed and light or medium pressure

[a] Corrosion resistance generally the same as for nonleaded alloys of similar composition.
[b] Values are given for the as-cast condition.

Leaded Brasses and Bronzes—Cast

BBII Grade ➡	Leaded Red Brass[a]		Leaded Semi-Red Brass[a]	
	4A	4B	5A	5B
COMPOSITION, %	Cu 85, Sn 5, Pb 5, Zn 5	Cu 83, Sn 4, Pb 6, Zn 7	Cu 81, Sn 3, Pb 7, Zn 9	Cu 76, Sn 3, Pb 6, Zn 15
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.314–0.321	0.311–0.314	0.311–0.318	0.309–0.314
Melting Temp Range, F	1840–1550	1800	1800	1775
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	36	—	—	—
Coef of Ther Exp (70–400 F), per °F	10.9×10^{-6}	—	—	—
Elec Cond (68 F), % IACS	15	—	18	—
MECHANICAL PROPERTIES[b]				
Mod of Elast in Tension, psi	$9.1\text{–}14.8 \times 10^6$	—	$7.7\text{–}14.3 \times 10^6$	$10\text{–}14 \times 10^6$
Ten Str, 1000 psi	33–46	30–38	29–39	30–40
Yld Str (0.5% ext), 1000 psi	17–24	12–17	13–17	12–16
Elongation (in 2 in.), %	20–35	15–27	18–30	20–35
Red. of Area, %	17–32	12–25	15–27	15–30
Hardness (Brinell)	55–65	50–60	50–60	50–60
Impact Str (Izod), ft-lb	6–12	—	6–10	—
Compr Yld Str (0.001-in. set), 1000 psi	10–12	11–12	—	8–10
FABRICATING PROPERTIES				
Casting Temp Range, F				
Light Castings	2100–2350	2100–2300	2100–2300	2100–2300
Heavy Castings	1950–2150	1950–2150	1950–2150	1950–2150
USES	Low pressure valve bodies, pipe fittings, pump impellers, plumbing goods	Air, gas and water fittings, valves, pump parts, hardware, carburetors	Low pressure valves and fittings, hardware, plumbing fittings	Plumbing fixtures, air and gas fittings, hardware, low pressure valves and fittings

BBII Grade ➡	Leaded Nickel Brass and Bronze[a]			
	10A	10B	11A	11B
COMPOSITION, %	Cu 57, Sn 2, Pb 9, Zn 20, Ni 12	Cu 60, Sn 3, Pb 5, Zn 16, Ni 16	Cu 64, Sn 4, Pb 4, Zn 8, Ni 20	Cu 66.5, Sn 5, Pb 1.5, Zn 2, Ni 25
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.318–0.322	0.318–0.322	0.318–0.322	0.318–0.322
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	16	16	14	15
Elec Cond (68 F), % IACS	5–7	5–6	4.5–5.5	4–5
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	$15\text{–}16.5 \times 10^6$	—	$17\text{–}18 \times 10^6$	$19\text{–}22 \times 10^6$
Ten Str, 1000 psi	30–40	35–45	40–60	50–65
Yld Str (0.5% extn), 1000 psi	15–20	17–24	17–30	26–40
Elongation (in 2 in.), %	10–25	15–30	15–25	15–25
Red. of Area, %	7–20	15–30	11–22	15–30
Hardness (Brinell)	50–60	65–80	76–120	120–150
FABRICATING PROPERTIES				
Casting Temp Range, F				
Light Castings	2200–2400	2250–2450	2300–2600	2400–2600
Heavy Castings	2000–2200	2050–2250	2250–2400	2300–2400
USES	Hardware fittings, valves and trim, plumbing fittings	Valves and fittings, boat and railroad car fittings, pipe fittings	Marine fittings, furniture trim, building trim, valves, hardware	Dairy and soda fountain parts, valves and seats for elevated temp

[a] Corrosion resistance generally the same as for nonleaded alloys of similar composition.
[b] Values are given for the as-cast condition.

Yellow Brasses—Cast

BBII Grade →	High Strength Yellow Brass[a]		
	7A	8A	8C
COMPOSITION, %	Cu 56–62, Sn 0.5–1, Pb 0.5–1, Fe 0.75–1.5, Al 0.25–1, Mn 0.1–0.5, Zn bal	Cu 56–59, Sn 1 max, Pb 0.3 max, Fe 0.75–2, Al 0.75–1.5, Mn 0.1–1, Zn bal	Cu 60–68, Pb 0.1 max, Fe 2–4, Al 4–7.5, Mn 3–4.5, Zn bal
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.289–0.303	0.289–0.307	0.278–0.289
Melting Temp Range, F	1675–1725	1660–1700	1650–1700
Coef of Ther Exp (70–400 F), per °F	11.4×10^{-6}	12×10^{-6}	11×10^{-6}
Electrical Conductivity (68 F), % IACS	20–24	16–20	10–14
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	$12\text{–}14 \times 10^{6}$	$13\text{–}15 \times 10^{6}$	$15\text{–}16.5 \times 10^{6}$
Tensile Strength, 1000 psi	60–78	70–88	110–120
Yield Strength (0.5% ext), 1000 psi	25–40	28–40	65–90
Elongation (in 2 in.), %	15–30	20–35	12–18
Red. of Area, %	15–30	20–40	5–18
Hardness (Brinell)	80–95	90–120	170–225
Impact Strength (Izod), ft-lb	20–40	20–40	7–12
Compr Yld Str (0.001-in. set), 1000 psi	20–26	22–26	55–65
FABRICATING PROPERTIES			
Casting Temp Range, F			
Light Castings	1900–2050	1900–2000	1950–2150
Heavy Castings	1750–1900	1750–1900	1800–1950
USES	Valve stems, marine castings, pump bodies, gears, brackets	Propeller hubs and blades, valve stems, machine parts, gears	Spur gears, cams, bridge parts, screw down nuts, bearings

BBII Grade →	Leaded Yellow Brass[a]		
	6A	6B	6C
COMPOSITION, %	Cu 71, Zn 25, Pb 3, Sn 1	Cu 67, Zn 29, Pb 3, Sn 1	Cu 60, Zn 37.75, Pb 1, Sn 1, Al 0.25
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.305–0.309	0.303–0.307	0.300–0.360
Melting Temp Range, F	1700–1750	1700–1725	1675–1725
Coef of Ther Exp (70–200 F), per °F	11.5×10^{-6}	11.2×10^{-6}	12×10^{-6}
Electrical Conductivity (68 F), % IACS	15–22	18–25	20–26
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	$11\text{–}14 \times 10^{6}$	$12\text{–}14 \times 10^{6}$	$13\text{–}15 \times 10^{6}$
Tensile Strength, 1000 psi	35–40	30–38	40–45
Yield Strength (0.5% ext), 1000 psi	12–14	11–15	14–20
Elongation (in 2 in.), %	25–40	20–35	15–25
Red. of Area, %	20–40	15–30	18–30
Hardness (Brinell)	40–55	40–60	50–75
Compr Yld Str (0.001-in. set), 1000 psi	8–10	8–10	—
FABRICATING PROPERTIES			
Casting Temp Range, F			
Light Castings	2000–2100	1950–2100	1950–2150
Heavy Castings	1850–2000	1850–1950	1800–2000
USES	Plumber's fittings and fixtures, ferrules, hardware, andirons	Valves and fittings, spray nozzles, battery clamps, ship fittings	Ship fittings, plumber's flanges, hardware, Navy yellow brass

[a] Corrosion resistance generally the same as for nonleaded alloys of similar composition.

Aluminum Bronzes—Cast

BBII Grade →	9A	9B	9C	9D
COMPOSITION, %	Cu 87.5, Al 9, Fe 3.5	Cu 89, Al 10, Fe 1	Cu 83 min, Al 10–11.5, Fe 3–5, Ni 2.5 max, Mn 0.5 max	Cu 81, Al 11, Fe 4, Ni 4
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.267	0.270	0.272	0.273
Melting Point Range, F	—	—	1880–1900	1937
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	—	33	—	22
Coef of Ther Exp, per °F	9.5×10^{-6} [a]	9.5×10^{-6} [b]	9.0×10^{-6} [b]	—
Elec Cond (68 F), % IACS	13	13.5	12	7.5
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	17×10^6	15×10^6	18×10^6	17×10^6
Ten Str, 1000 psi				
Sand Cast	75	87	75	95
Sand Cast & Heat Treated	—	90[c]	105[d]	115[e]
Yld Str (0.5% ext), 1000 psi				
Sand Cast	27	32	35	45
Sand Cast & Heat Treated	—	40[e]	52[d]	70[e]
Elongation (in 2 in.), %				
Sand Cast	35	27	18	7
Sand Cast & Heat Treated	—	15[c]	10[d]	5[e]
Hardness (Brinell)				
Sand Cast	120	120	155	195
Sand Cast & Heat Treated	—	180[c]	230[d]	235[e]
THERMAL TREATMENT				
Normalizing Temp, F	Heat to 1500, furnace cool to 1000, air cool			
Quenching Temp, F	1600–1700	1600–1700	1600–1700	1600–1700
Tempering Temp, F	700–1200	700–1200	700–1200	700–1200
FABRICATING PROPERTIES				
Castability	Because of narrow freezing ranges and high shrinkage, aluminum bronzes are difficult to cast. In addition, they are sensitive to gases. In melting, precautions must be taken to minimize stirring and breaking the oxide skin on the surface of the melt to prevent absorption of gases. In pouring, agitation must be avoided, and castings are generally bottom gated to reduce turbulence. Shrinkage difficulties are overcome by use of large risers (to feed the casting) and chills			
Machinability Index (free-cutting brass = 100)	20–30	20–30	20–30	20–30
Weldability	Can be welded by carbon arc, inert-gas arc and resistance methods. Can be brazed with silver brazing alloys, but require special fluxes			
CORROSION RESISTANCE	Generally good resistance to atmosphere, water and salt water, and salt solutions. Some resistance to alkaline solutions and nonoxidizing inorganic acids. Poor resistance to ammonia compounds, ferric salts and oxidizing inorganic acids			
USES	Machine parts, pump impellers and castings, gears, rolling mill bearings, segments and washers, bearings, chemical plant equipment, pickling equipment such as chains and hooks, marine propellers, pump casings, fittings			

[a] 70-250 F. [b] 70-500F.
[c] Water quenched from 1625 F, tempered at 1125 F, water quenched.
[d] Water quenched from 1625 F, tempered at 1000 F, water quenched.
[e] Water quenched from 1625 F, tempered at 1150 F, water quenched.

Lead and Its Alloys—Cast, Wrought[a]

Type ➡	Chemical Lead	Common Lead (soft lead)	Tellurium Lead
COMPOSITION, %	Pb 99.90+	Pb 99.73+	Te 0.05, Cu 0.06 max
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.41	0.41	0.41
Melting Point, F	618	621	617
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	19.6	19.6	19.3
Coef of Ther Exp, per °F	16.3×10^{-6}	16.3×10^{-6}	16×10^{-6}
Specific Heat (32 F), Btu/lb/°F	0.031	0.031	0.031
Electrical Resistivity (68 F), microhm-cm	—	20.6	—
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	2×10^6	2×10^6	1.5×10^6
Tensile Strength, psi			
Rolled	2450	2090	—
Extruded	2200	2000	—
Sand Cast	—	1800	—
Chill Cast	2200	2000	—
Yield Strength, psi			
Rolled	1640	—	—
Extruded	—	—	1500
Sand Cast	—	800	—
Elongation (in 2 in.), %			
Rolled	57	43	40
Extruded	48	—	—
Sand Cast	—	30	—
Chill Cast	40	47	—
Reduction of Area, %			
Sand Cast	—	100	—
Chill Cast	—	100	—
Hardness (Brinell)			
Extruded	—	—	6
Sand Cast	—	3.2-4.5	—
Chill Cast	—	4.2	—
Impact Strength (Charpy, chill cast), ft-lb	—	10	—
Endurance Limit (10^7 cycles), psi			
Extruded & Aged	725	470	1000
Sand Cast	—	470	—
Shear Strength, psi			
Sand Cast	—	1820	—
Chill Cast	—	1820	—
Creep Strength (0.1% per yr, rolled, 85 F), psi	300	250	300
FABRICATING PROPERTIES	Formed by cold rolling and extrusion		
Casting Temp Range, F	790-850	790-850	790-850
Joining	Soft solder with 50-50 or 40-60 solder using rosin or stearic acid flux. Oxyhydrogen welding (lead burning); slightly reducing flame; no flux		
CORROSION RESISTANCE	Resistant to sulfuric, sulfurous, phosphoric and chromic acids. Attacked by acetic, formic and nitric acids. Resistant to atmosphere and fresh and salt water		
AVAILABLE FORMS	Castings, rolled and extruded shapes, sheet		
USES	Nuclear reflectors and shields; anodes for cathodic protection		
	Chemical apparatus	Storage batteries, cable sheath, ammunition, calking, alloying, coatings, liquid baths for heat treating	Chemical apparatus

[a] See also Tin-Lead-Antimony Alloys.

Lead and Its Alloys—Wrought

Type ➡	1% Sb-Lead	Hard Lead	Hard Lead	8% Sb-Lead	Grid Metal (7-12% Sb)
COMPOSITION, %	Sb 1	Sb 4	Sb 6	Sb 8	Sb 9
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.406	0.398	0.393	0.388	0.385
Melting Temp Range, F	608-595	570-486	545-486	520-486	509-486
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	19	18	17	16	16
Coef of Ther Exp (68-212 F), per °F	16×10^{-6}	15.5×10^{-6}	15.4×10^{-6}	14.5×10^{-6}	14.4×10^{-6}
Spec Ht, Btu/lb/°F	0.031	0.032	0.032	0.032	0.032
Elec Res (68 F), microhm-cm	22	24	25	26.5	27.1
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	2×10^6	—	—	—	—
Ten Str, 1000 psi					
Rolled	3.0	4.0	4.1	4.6	4.7
Extruded	2.9	3.1	3.3	3.3	—
Extruded & Aged	3.0	—	—	—	—
Chill Cast	3.4	5.6	6.8	7.4	7.4
Elong (in 2 in.), %					
Rolled	60	48	47	31	17
Extruded	58	58	65	75	—
Extruded & Aged	50	—	—	—	75
Chill Cast	16	22	24	19	—
Hardness (Brinell)					
Rolled	5.9	8	—	9.5	7.8
Extruded	5.1	8.9	10.7	12.4	—
Extruded & Aged	7	—	—	—	—
Chill Cast	7	10	11.8	13.3	15.4
Endurance Limit, psi[a]					
Rolled	—	1500	1500	1750	—
Extruded	—	—	1200	—	—
Extruded & Aged	1150	—	—	—	—
Chill Cast	—	—	2500	—	2700
Creep Str (86 F)[b]					
Rolled	—	250	400	425	400
Extruded	350	210	—	—	—
FABRICATING PROPERTIES					
Casting Temp Range, F	750-925	750-925	750-850	750-925	750-925
Joining	Soft solder with 50-50 or 40-60 solder using rosin or stearic acid flux. Oxyhydrogen welding (lead burning): no flux, slightly reducing flame				
CORROSION RESISTANCE	Similar to soft lead (see opposite page)				
USES	Nuclear reflectors and shields; anodes for cathodic protection				
	Cable sheathing	Rolled sheet for roofing and flashing; extruded pipe for corrosion resistance applications requiring greater strength than soft lead			Battery grids

[a] 2×10^7 cycles.
[b] 1% extension in 10,000 hr.

Magnesium Alloys—Wrought

ASTM Type →	AZ31B-F	AZ61A-F	AZ80A-T5	ZK60A-T5	(P)ZK60B-T5	ZK21A-F
COMPOSITION, %	Mn 1.20 min	Al 5.8–7.2, Zn 0.4–1.5, Mn 0.15 min	Al 7.8–9.2, Zn 0.2, Mn 0.15 min	Zn 4.8–6.2, Zr 0.45 min	Zn 4.8–6.8, Zr 0.45 min	Zn 2.0–2.6, Zr 0.45–0.8
PHYSICAL PROPERTIES						
Density, lb/cu in.	0.064	0.065	0.065	0.066	0.066	0.064
Melting Temp Range, F	1050–1170	950–1140	900–1115	968–1175	968–1175	—
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	44	34	29	68–70	70	—
Coef of Ther Exp, per °F						
68 F	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}
68 to 750 F	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.245	0.245	0.245	0.245	0.245	0.245
Elec Res (68 F), microhm-cm	9.2	12.5	14.5	6.0–5.7	5.7	—
MECHANICAL PROPERTIES						
Mod of Elast in Tension, psi	6.5×10^{6}	6.5×10^{6}	6.5×10^{6}	6.5×10^{6}	6.5×10^{6}	6.5×10^{6}
Ten Str, 1000 psi						
Extruded[a]	36–38	41–46	50–55	50–53	49	41–42
Forged	38	43	50	49	50	38
Yld Str, 1000 psi						
Extruded[a]	24–28	24–33	38–40	40–44	38	33–35
Forged	28	26	34	38	40	28
Elong (in 2 in.), %						
Extruded[a]	12–16	14-17	6–8	11–14	17	6–10
Forged	9	12	6	13	10	15
Compr Yld Str, 1000 psi						
Extruded[a]	12–14	16–21	31–34	30–36	40	17–25
Forged	16	17	28	28	38	16
Hardness (Brinell)						
Extruded[a]	46–49	50–60	82	82	—	—
Forged	55	55	72	—	—	—
Shear Str, 1000 psi						
Extruded	19	20	24	24–26	26	—
Forged	19	20	23	—	—	—
Fatigue Strength[b] (10^8 cycles), 1000 psi						
Extruded	16–20	18–23	20–24	17–23	17–23	—
Forged	—	17–22	16–18	16–18	—	—
Impact Str (Charpy), ft-lb						
Extruded	5.0	4.5	1.3	3	2.6	—
Forged	—	—	—	—	—	—
FABRICATING PROPERTIES						
Hot Working Temp Range, F[d]	450–550	450–650	350–375	300–500	300–500	300–500
Weldability[c]						
Inert-Gas Arc	A	B	B	D	D	B
Elec Res	A	A	A	A	A	A
Stress Relief Temp, F	500	500	400	—	—	—
Machinability Index (free-cutting brass=100)	500	500	500	500	500	500
Hot Formability[c]	A	B	C	A	A	A
Cold Formability[c]	B	C	D	C	C	C
CORROSION RESISTANCE	Good resistance to atmosphere; attacked by salt water unless finished					
AVAILABLE FORMS	Rod, bar, extruded shapes, tubing (except AZ80A), forgings				Rod, bar, extruded shapes	Rod, bar, extruded shapes, tubing
USES	Aircraft and missile parts, ordnance vehicles, automotive and truck parts, electronic equipment, wave guides, office machines, reciprocating machinery parts, drillable oil well casing tools, hand tools, levels, material handling equipment, concrete forms, plastering tools, jigs and fixtures, luggage and furniture, boats, sporting goods, wheels					

[a] Generally, strengths and hardness of extruded bar are highest, extruded tubing lowest, and extruded shapes intermediate in the ranges of values given.
[b] Rotating-beam fatigue.
[c] Letter A indicates most favorable, B less favorable, etc. Relative to magnesium alloys only.
[d] Higher working temperatures can be used if they do not require heating aged alloys above the aging temperature.

Magnesium Alloys—Wrought

ASTM Type ➔	ZE10A-H24 [a]	AZ31B-H24 [b]	HK31A-H24 [a]	HM21A-T8	HM31A-T5
COMPOSITION, %	Zn 1.0–1.5, Rare earths 0.12–0.22	Al 2.5–3.5, Zn 0.7–1.3, Mn 0.20	Th 2.5–4.0, Zr 0.45–1.0	Th 1.5–2.5, Mn 0.45–1.1	Th 2.5–3.5, Mn 1.2 min
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.063	0.064	0.065	0.064	0.065
Melting Temp Range, F	1100–1195	1050–1170	1092–1195	1121–1202	1121–1202
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	77	44	66	79	60
Coef of Ther Exp (68 to 750 F), per °F	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.245	0.245	0.245	0.245	0.245
Elec Res (68 F), microhm-cm	5.2	9.2	6.1	5.0	6.6
MECHANICAL PROPERTIES [c]					
Mod of Elast in Tension, psi					
75 F	6.5×10^6	6.5×10^6	6.4×10^6	6.4×10^6	6.5×10^6
500 F	—	—	5.2×10^6	5.8×10^6	5.7×10^6
Ten Str, 1000 psi [d]					
75 F	34–38	42, 38–39	37	34	42
500 F	—	—	20	15	21
Yield Str, 1000 psi [d]					
75 F	19–28	32, 24–27	29	21	33
500 F	—	—	17	13	19
Elong (in 2 in.), % (75 F) [d]	8–12	15, 18–19	8	10	10
Compr Yld Str, 1000 psi [d]					
75 F	16–26	24–25, 12–14	23	15	25
500 F	—	—	20	13	19
Shear Str, 1000 psi [d]					
75 F	—	23, —	27	19	23
500 F	—	—	12	11	11
Fatigue Str, 1000 psi [e]					
75 F	20–24	20–24	18–20	16–18	12–14
400 F	—	—	9–14	12–14	—
Creep Str (stress to give 0.5% total ext in 100 hr), 1000 psi					
300 F	—	1.5	20	16	21
500 F	—	—	—	9	13
FABRICATING PROPERTIES					
Hot Working Temp Range, F	325–425	325–425	550–700	650–800	650–800
Weldability [f]					
Inert-Gas Arc	A	A	A	A	A
Elec Res	A	A	A	A	A
Stress Relief Temp, F	—	500	—	—	—
Machinability Index (free-cutting brass=100)	500	500	500	500	500
Hot Formability [f]	A	A	A	A	A
Cold Formability [f]	B+	B	C	C	C
CORROSION RESISTANCE	Good resistance to atmosphere; attacked by salt water unless finished				
AVAILABLE FORMS	Sheet and plate				Extrusions
USES	Aircraft and missile parts, ordnance vehicles, truck bodies, electronic cabinets, chassis, covers and reflectors, office machines, appliances, materials handling equipment, concrete forms, jigs and fixtures, templates, foundry pattern plate, deck plate, photoengraving plate, luggage, furniture, sporting goods		Aircraft and missile components		

[a] ZE10A and HK31A also available in -0 temper.
[b] AZ31B sheet and plate also available in -0 temper. AZ31B plate also available in -H26 temper. AZ31B also available as special bending sheet in the -0 temper and 0.040-0.190-in. thickness for cold bending around a mandrel radius of 2-3 or more times the sheet thickness.
[c] HM31A-T5 properties for extrusions (to 4 sq in.) only. ZE10A-H24, HM21A-T8 and HK31A-H24 properties for sheet only. AZ31B-H24 properties for sheet only except as indicated.
[d] AZ31B-H24 values are for sheet and plate, respectively.
[e] Axial load fatigue of ZE10A-H24 and AZ31B-H24 sheet, 10^7 cycles, R = 1/3. Axial load fatigue of HM21A-T8 and HK31A-H24 sheet, 10^7 cycles, R = 1/4. Rotating beam fatigue of HM31A-T5 extrusions, 10^8 cycles, R = 1.
[f] Letter A indicates most favorable, B less favorable, etc. Relative to magnesium alloys only.

Magnesium Alloys—Cast

ASTM Type →	AZ63A	AZ81A	AZ91A	AZ91C	AZ92A	AM100A
COMPOSITION, %	Al 5.3–6.7, Zn 2.5–3.5, Mn 0.15 min	Al 7.0–8.1, Zn 0.40–1.0, Mn 0.13 min	Al 8.3–9.7, Zn 0.4–1.0, Mn 0.13 min	Al 8.1–9.3, Zn 0.40–1.0, Mn 0.13 min	Al 8.3–9.7, Zn 1.6–2.4, Mn 0.10 min	Al 8.3–9.7, Zn 0.3 max, Mn 0.10 min
PHYSICAL PROPERTIES						
Density, lb/cu in.	0.066	0.065	0.065	0.065	0.066	0.065
Melting Temp Range, F	850–1135	1115	875–1120	875–1105	830–1110	865–1100
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	29–39	29	31	27–31	27–34	24–34
Coef of Ther Exp, per °F						
68 F	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}
68–750 F	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.245	0.245	0.245	0.245	0.245	0.245
Elec Res (68 F), microhm-cm	11–14	15	14	13–16	12–17	11–17
MECHANICAL PROPERTIES[a]						
Mod of Elast in Tension, psi	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6
Ten Str, 1000 psi						
As Cast	29	—	34	24	24	22
Sol'n Treated	40	40	—	40	40	40
Aged[b]	30, 40	—, —	—, —	—, 40	26, 40	—, 40
Yld Str, 1000 psi						
As Cast	14	—	23	14	14	12
Sol'n Treated	13	12	—	12	14	13
Aged[b]	14, 19	—, —	—, —	—, 19	16, 21	—, 16
Elong (in 2 in.), %						
As Cast	6	—	3	2	2	2
Sol'n Treated	12	15	—	14	9	10
Aged[b]	4, 5	—, —	—, —	—, 5	2, 2	—, 4
Hardness (Brinell)						
As Cast	50	—	60	52	65	—
Sol'n Treated	55	55	—	53	63	—
Aged[b]	55, 73	—, —	—, —	—, 66	80, 84	—, —
Shear Str, 1000 psi						
As Cast	16	—	20	16	16	—
Sol'n Treated	17	17	—	17	17	—
Aged[b]	17, 19	—, —	—, —	—, 19	16, 20	—, —
Fatigue Str (10^8 cycles), 1000 psi[c]						
As Cast	9–12	—	10–14	11–14	12–14	—
Sol'n Treated	12–17	11–14	—	12–15	12–15	—
Sol'n Treated and Aged	11–15	—	—	10–13	11–15	—
THERMAL TREATMENT						
Solution Temp, F	730	780	—	780	770	780
Aging Temp, F	425	—	—	420	500	425
FABRICATING PROPERTIES						
Weldability[d]						
Inert-Gas Arc	D	B	—	C	C	A
Stress Relief Temp, F	500	500	—	500	500	500
Machinability Index (free-cutting brass=100)	500	500	500	500	500	500
CORROSION RESISTANCE	Good resistance to atmosphere; attacked by salt water unless finished					
AVAILABLE FORMS	Sand and permanent mold castings		Die castings	Sand and permanent mold castings		Permanent mold castings
USES	Wheels, aircraft and missile parts, ordnance equipment, automotive and truck parts, electronic housings, office machines, appliances, reciprocating machinery parts, cameras and optical equipment, hand tools, material handling equipment, sporting goods, griddles					

[a] Separately-cast test bars.
[b] First value obtained by artificial aging only; second value by solution treating and artificial aging.
[c] Rotating-beam fatigue.
[d] Letter A indicates most favorable, B less favorable, etc. Relative to magnesium alloys only.

Magnesium Alloys—Cast

ASTM Type ➜	ZE41A-T5	ZK51A-T5	ZH62A-T5	K1-A
COMPOSITION, %	Zn 3.5–5.0, rare earths 0.75–1.75, Zr 0.40–1.0	Zn 3.6–5.5, Zr 0.55–1.0	Zn 5.2–6.2, Th 1.4–2.2, Zr 0.50–1.0	Zr 0.7
PHYSICAL PROPERTIES				
Density, lb/cu in	0.066	0.065	0.067	0.063
Melting Temp Range, F	—	1040–1175	—	1202[d]
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	—	48	63	60
Coef of Ther Exp, per °F				
68 F	14×10^{-6}	14×10^{-6}	14×10^{-6}	—
68–750 F	16×10^{-6}	16×10^{-6}	16×10^{-6}	15×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.245	0.245	0.245	—
Elec Res (68 F), microhm-cm	—	8.4	6.5	5.7
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension, psi	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6
Ten Str, 1000 psi	30	40	40	26
Yld Str, 1000 psi	20	24	25	8
Elong (in 2 in.), %	3.5	8	6	19
Hardness (Brinell)	62	65	62	—
Shear Str, 1000 psi	22	22	23	8
Fatigue Str (10^8 cycles), 1000 psi[b]	—	8–10	—	—
THERMAL TREATMENT				
Aging Temp, F	350	350	350	—
FABRICATING PROPERTIES				
Weldability (inert-gas arc)[c]	B	D	D	B
Machinability Index (free-cutting brass=100)	500	500	500	500
CORROSION RESISTANCE	Good resistance to atmosphere; attacked by salt water unless finished			
AVAILABLE FORMS	Sand and permanent mold castings			Sand and die castings
USES	Aircraft and missile parts, ordnance equipment			

[a] Separately-cast test bars.
[b] Rotating-beam fatigue.
[c] Letter A indicates most favorable, B less favorable, etc. Relative to magnesium alloys only.
[d] Melting point.

continued on next page

Magnesium Alloys—Cast

ASTM Type →	QE22A-T6	EZ33A-T5	HK31A-T6	HZ32A-T5	EX31XA-T6
COMPOSITION, %	Ag 2.0–3.0, rare earths[d] 1.75–2.25, Zr 0.40–1.0	Rare earths[e] 2.5–4.0, Zn 2.0–3.1, Zr 0.50–1.0	Th 2.5–4.0, Zr 0.50–1.0	Th 2.5–4.0, Zn 1.7–2.5, Zr 0.50–1.0	Rare earths[d] 2.5–4.0, Zr 0.4–1.0
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.065	0.066	0.065	0.066	0.064
Melting Temp Range, F	—	1110–1189	1092–1195	1026–1198	—
Ther Cond, Btu/hr/sq ft/°F/ft					
68 F	—	58	52	62	36
600 F	—	69	68	74	43
Coef of Ther Exp, per °F					
68 F	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}	14.5×10^{-6}
68–750 F	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}	14.5×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.245	0.245	0.245	0.245	—
Elec Res, microhm-cm					
68 F	—	7.0	7.7	6.5	7.2
600 F	—	12.1	12.4	11.3	12.0
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension, psi					
75 F	—	6.5×10^6	6.5×10^6	6.5×10^6	—
300 F	—	6.0×10^6	6.1×10^6	5.9×10^6	—
600 F	—	5.4×10^6	5.6×10^6	5.6×10^6	—
Ten Str, 1000 psi					
75 F	40	23	31	29	35
400 F	28	21	24	17	29
700 F	7	—	13	10	15[f]
Yld Str, 1000 psi					
75 F	30	16	16	15	22
400 F	25	12	14	10	20
700 F	6	—	8	7	13[f]
Elong (in 2 in.), %, 75 F	4	3	6	6	5
Hardness (Brinell)	—	50	55	57	64
Shear Str, 1000 psi					
75 F	—	20	21	20	23
400 F	—	17	16	14	19
600 F	—	10	13	10	11
Fatigue Str, 1000 psi[b] (10^8 cycles), 75 F	15-17	9-11	9-11	9-11	—
Creep Str (stress to give 0.5% total ext in 100 hr), 1000 psi					
400 F	14	10	15	10	10-13
500 F	—	4	10	8	3-4
600 F	—	1.5	3.5	5	1.2-1.8
FABRICATING PROPERTIES					
Weldability (inert-gas arc)[c]	—	A	A	A	—
Machinability Index (free-cutting brass=100)	500	500	500	500	—
CORROSION RESISTANCE	Good resistance to atmosphere; attacked by salt water unless finished				
AVAILABLE FORMS	Sand and permanent mold castings				Sand castings
SERVICE TEMPERATURE, MAXIMUM, F	500	500	700	700	550
USES	Aircraft and missile components				Aircraft and missile components up to 550 F; airframe and engine components for 1000 hr at 450 F

[a] Separately-cast test bars. [b] Rotating-beam fatigue.
[c] Letter A indicates most favorable, B less favorable, etc. Relative to magnesium alloys only.
[d] Rare earths are present as didymium, essentially 85% neodymium and 15% praseodymium.
[e] Rare earths are present as mischmetal. [f] At 600 F.

Columbium, Tantalum, Tungsten, Molybdenum—Wrought

Metal →	Columbium	Tantalum	Tungsten	Molybdenum
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.31	0.60	0.70	0.37
Melting Point, F	4379	5425	6170	4760
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	31.5	31.5	96.6	84.5
Coef of Ther Exp (70 F), per °F	3.82×10^{-6} [a]	3.6×10^{-6}	2.2×10^{-6}	3.0×10^{-6}
Specific Heat, Btu/lb/°F	0.065	0.036	0.034	0.065
Elec Res (68 F), microhm-cm	14.2	12.4	5.48[b]	5.17[b]
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	15×10^6	27×10^6	50×10^6	45×10^6
Ten Str, 1000 psi				
Cold Worked	75–85	100	180–200	135–145[c]
Stress Relieved	35–45	60–70	150–170	105–115
Recrystallized	25–35	40–50	90–110	75–85
Yld Str, 1000 psi				
Cold Worked	65–75	90–95	160–180	120–130[c]
Stress Relieved	25–35	50–60	130–150	95–105
Recrystallized	20–30	30–40	80–100	70–80
Elong (in 2 in.), %				
Cold Worked	15–20	10–15	—	5–15[c]
Stress Relieved	30	40	—	15–20
Recrystallized	30–40	30–40	—	25–35
Hardness (VHN)				
Cold Worked	160–180	160	450	290–310[c]
Stress Relieved	120–130	130	420–440	250–270
Recrystallized	70–80	75	280–310	200–220
FABRICATING PROPERTIES				
Workability	Easily cold worked	Easily cold worked	Must be hot worked except fine wire	Thin sheet and wire can be cold worked
Annealing Temp, F	1950 in vacuum	1950 in vacuum	1830 in protective atm	Anneal to specified properties
Machinability	Like cold rolled steel, with proper lubricants; similar to copper	Like cold rolled steel, with proper lubricants; similar to copper	Difficult but can be machined with carbide tools; no lubrication needed	Like cast iron, but tool life is shorter; lubricant not required
Joining	Weldable to itself and other metals by resistance or inert arc welding. Special methods necessary	Weldable to itself and other metals by resistance or inert arc welding. Special methods necessary	Weldable to itself by inert arc with special methods; to other metals by brazing or resistance welding	Thin sheet can be resistance welded, heavier sections inert arc welded with special methods. Can be brazed
CORROSION RESISTANCE	Res to most acids (except hydrofluoric); res to most liquid metals. Less res to alkalis	More res than columbium to acids (except hydrofluoric); res to most liquid metals and metallic salts. Less res to alkalis	Res most acids and alkalis to 212 F, attacked by nitric-hydrofluoric mixture at rm temp, by aqua regia at 212 F	Moderately res to acids and alkalis up to 212 F, attacked by nitric-hydrofluoric mixture at rm temp, by aqua regia at 212 F
AVAILABLE FORMS	Bar, rod, wire, sheet, foil, tubing, powder, fabricated parts		Bar, rod, wire, sheet, powder, fabricated parts	Bar, rod, wire, sheet, tubing, powder, fabricated parts
USES	Nuclear reactors, missiles, rockets, chemical plant equipment, electronic tubes	Capacitors, chemical plant equipment, electronic tubes, rectifiers, surgical implants, nuclear reactors, missiles, rockets, aircraft	Lamp filaments, electrical contacts, nuclear reactors, rockets, missiles, aircraft, radiation shields, electronic tube parts, x-ray targets	Glass melting electrodes, electronic tube parts, furnace heating elements, electrical contacts, aircraft, missile and rocket structures, guidance systems

[a] 32–1832 F. [b] 32 F. [c] From powder.

Nickel and Its Alloys—Wrought

Type →	A Nickel	Low Carbon Nickel	Duranickel	Monel	K Monel
COMPOSITION, %	Ni 99.50, C 0.06, Mn 0.25, Fe 0.15, S 0.005, Si 0.05, Cu 0.05	Ni 99.50, C 0.01, Mn 0.20, Fe 0.15, S 0.005, Si 0.05, Cu 0.05	Ni 94.00, C 0.15, Mn 0.25, Fe 0.15, S 0.005, Si 0.55, Cu 0.05, Al 4.50, Ti 0.50	Ni 66.00, C 0.12, Mn 0.90, Fe 1.35, S 0.005, Si 0.15, Cu 31.50	Ni 65.00, C 0.15, Mn 0.60, Fe 1.00, S 0.005, Si 0.15, Cu 29.50, Al 2.80, Ti 0.50
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.321	0.321	0.298	0.319	0.306
Melting Temp Range, F	2615–2635	2615–2635	2550–2620	2370–2460	2400–2460
Ther Cond (80–212 F), Btu/hr/sq ft/°F/ft	36	36	10.7–11.2	15	10.8
Coef of Ther Exp (80–212 F), per °F	7.4×10^{-6}	7.4×10^{-6}	7.2×10^{-6}	7.8×10^{-6}	7.8×10^{-6}
Specific Heat (80–212 F), Btu/lb/°F	0.130	0.130	0.104	0.1 3	0.127[d]
Elec Res (32 F), microhm-cm	9.5	8.3	46.5 (soft)	48.2[e]	58.1[e]
Magnetic?	Yes	Yes	Yes	Slightly	No to −150 F
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension, psi	30×10^6	30×10^6	30×10^6	26×10^6	26×10^6
Tensile Strength, 1000 psi					
Annealed	55–75	50–60	90–120	70–85	90–105
Annealed, Age Hardened	—	—	160–190	—	130–170
Spring	90–130	—	155–190	100–140	145–165
Spring, Age Hardened	—	—	180–230	—	170–200
Yield Strength, 1000 psi					
Annealed	15–30	12–25	35–60	25–45	40–65
Annealed, Age Hardened	—	—	—	—	90–120
Spring	70–115	—	—	90–130	130–160
Spring, Age Hardened	—	—	—	—	130–180
Elongation (in 2 in.), %					
Annealed	55–40	60–40	50–30	50–35	45–25
Annealed, Age Hardened	—	—	25–10	—	25–15
Spring	15–2	—	10–2	15–2	8–3
Spring, Age Hardened	—	—	15–5	—	10–5
Hardness (Rockwell)					
Annealed	B64 (max)	B55 (max)[g]	B90 (max)	B68 (max)[g]	B85 (max)
Annealed, Age Hardened	—	—	C30–40 (min)	—	C24 (min)
Spring	B95 (min)	—	C30–40 (min)	B98 (min)	C25 (min)
Spring, Age Hardened	—	—	C36–46 (min)	—	C34 (min)
Endurance Limit (10^8 cycles), 1000 psi					
Hot Rolled	33[c]	33[c]	51	—	—
Cold Drawn	50[c]	50[c]	51	—	—
THERMAL TREATMENTS[a]					
Annealing Temperature, F	1500 (2–5 min)	1500 (2–5 min)	1600 (2–5 min)	1600–1800 (open), 1400–1500 (box)	1400–1800 (1–5 min)
Aging Temperature, F	—	—	1100 (8–16 hr)	—	1100 (8–16 hr, f.c.)[f]
FABRICATING PROPERTIES					
Hot Working Temp Range, F					
Heavy Forging, Drop Forging	1600–2300	1400–2300	1900–2300	1700–2150	1900–2150
Light Forging	1200–1600	1200–1600	1600–1900	—	—
Cutting Speed, fpm[b]	—	—	—	125–225	100–200
Joining	Metallic arc, inert-gas metal arc, oxy-acetylene and resistance welding; silver and copper brazing; soft soldering		Metallic arc, inert-gas metal arc and resistance welding; silver brazing; soft soldering	Metal arc, inert-gas tungsten arc, oxy-acetylene and resistance welding; silver and copper brazing; soft soldering	
AVAILABLE FORMS	Sheet, strip, rod, bar, shapes, tube, plate, wire		Strip, rod, bar, shapes, wire	Sheet, strip, rod, bar, shapes, tube, plate	
USES	Parts requiring good resistance to chlorides and caustic soda	Equipment handling molten salts; long time service at 700–1200 F	Parts requiring corrosion resistance and strength	Parts requiring combination of good strength, ductility and corrosion resistance	Parts requiring greater strength and hardness than monel

[a] Values are for sheet and strip unless otherwise specified.
[b] Surface speed with single point cemented carbide tools.
[c] Rod.
[d] 77–750 F.
[e] 68 F.
[f] Furnace cool.
[g] Strip only.

Nickel and Its Alloys—Cast

Type →	Nickel	Inconel[a]	S Inconel	Monel	S Monel
COMPOSITION, %	Ni 95.60, C 0.80, Mn 0.80, Fe 0.50, Si 1.50, Cu 0.50	Ni 68.50, C 0.20, Mn 1.00, Fe 9.00, Si 1.60, Cu 0.50, Cr 15.50, Cb+Ta 2.00	Ni 68.00, C 0.20, Mn 1.00, Fe 8.00, Si 5.50, Cu 0.50, Cr 15.50	Ni 64.00, C 0.20, Mn 0.80, Fe 1.00, Si 1.50, Cu 31.50	Ni 63.00, C 0.10, Mn 0.80, Fe 2.00, Si 4.00, Cu 29.50
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.301	0.300	0.292	0.312	0.302
Melting Temp Range, F	2450–2600	2500–2550	—	2400–2450	2300–2350
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	34.2	8.7	—	15.5	11.3
Coef of Ther Exp (70–1400 F), per °F	8.9×10^{-6}	8.92×10^{-6}	9.20×10^{-6}	9.1×10^{-6}	8.9×10^{-6}
Spec Ht (80–750 F), Btu/lb/°F	0.13	0.11	—	0.13	0.13
Elec Res (32 F), microhm-cm	20.8	11.6	12.6	53.2	65.3
Magnetic Trans Temp, F	680	−40	—	110–140	−70
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	21.5×10^{6}	23×10^{6}	25×10^{6}	19×10^{6}	24.2×10^{6}
Ten Str, 1000 psi					
Annealed and Aged	—	—	90–130	—	110–145
As Cast	45–60	70–95	90–120	65–90	110–145
Yld Str (0.5% ext), 1000 psi					
Annealed and Aged	—	—	85–105	—	80–115
As Cast	20–30	30–45	80–100	32–45	80–115
Elong (in 2 in.), %					
Annealed and Aged	—	—	4–1	—	1–4
As Cast	30–15	30–10	3–1	25–45	1–4
Hardness (Brinell)					
Annealed and Aged	—	—	300–380	—	300–380
As Cast	80–125	190	300–380	125–150	275–350
Impact Str (Charpy, rm temp), ft-lb	60	60	—	70	4
FABRICATING PROPERTIES					
Pouring Temp, F	2700–2900	2800–2950	2700–2900	2700–2850	2650–2800
Pattern Shrinkage, in./ft	0.25	0.25	0.25	0.25	0.25
Weldability	Fabrication or repair by any standard process[b]	Weldable by any standard process	Welding not recommended	Limited amount of repair welding[a]	Welding not recommended
CORROSION RESISTANCE	Good corrosion resistance, especially to hot concentrated caustic soda, and chlorine and fluorine gases	Resistance to nitric acid, ammonium hydroxide and oxidizing conditions superior to that of nickel. Good resistance to oxidation at temperatures up to 2200 F. Good resistance to corrosive vapors above 800 F		Good resistance to flowing salt water; dilute acids; hydrochloric, hydrofluoric, sulfuric, phosphoric and most organic acids; and strong caustic soda. Not resistant to strongly oxidizing solutions such as nitric acid and ferric chloride	
USES	Evaporators, tanks, heating coils, tubular condensers and other processing equipment; magnetostrictive devices; applications in incandescent lamp and radio industries	Dairy equipment, food handling equipment, airplane exhaust manifolds, utensils. Used extensively in oxidizing and carburizing atmospheres at elevated temperatures. Inconel S castings have higher resistance to wear and galling than Inconel		Valve seats, liners, pump rods, bushings, nozzles, turbine blading, pickling equipment, laundry machines, paper mill and oil refinery equipment, food handling equipment, storage tanks, boilers. Monel S castings have higher resistance to galling and erosion than Monel	

[a] Composition is for weldable grade. [b] For joining by welding, a weldable grade is available.

Low-Expansion Nickel Alloys—Wrought

Composition (%)* →	Ni 36	Ni 42	Ni 47-50
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.291	0.294	0.296
Melting Point, F	2600	2600	2600
Ther Cond (68-212 F), Btu/hr/sq ft/°F/ft	7.8	8.9	10.3
Coef of Ther Exp, per °F			
−200 to 0 F	1.10×10^{-6}	3.42×10^{-6}	5.37×10^{-6}
0 to 200 F	0.70×10^{-6}	3.18×10^{-6}	5.55×10^{-6}
200 to 400 F	1.50×10^{-6}	2.97×10^{-6}	5.55×10^{-6}
400 to 600 F	6.35×10^{-6}	3.15×10^{-6}	5.55×10^{-6}
600 to 800 F	8.61×10^{-6}	5.50×10^{-6}	5.60×10^{-6}
800 to 1000 F	9.48×10^{-6}	8.55×10^{-6}	7.26×10^{-6}
Specific Heat (77-212 F), Btu/lb/°F	0.123	0.121	0.120
Electrical Resistivity (68 F), microhm-cm	81	70	48
Poisson's Ratio	0.290	0.290	0.290
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	21×10^6	22×10^6	24×10^6
Tensile Strength, 1000 psi			
Annealed	71	68	77
Cold Worked	90	120	140
Yield Point, 1000 psi			
Annealed	40	39	33
Cold Worked	70	—	—
Elongation (in 2 in.), %			
Annealed	43	49	45
Cold Worked	20	—	—
Reduction of Area, %			
Annealed	75	79	75
Cold Worked	60	—	—
Hardness			
Annealed (Brinell)	132	138	144
Cold Worked (Rockwell)	B90	B100	B103
Modulus of Rigidity, psi	8.1×10^6	8.5×10^6	9.3×10^6
FABRICATING PROPERTIES			
Annealing Temp, F	Usually about 1450 F		
Hot Working Temp Range, F	To 2300 F	To 2300 F	To 2300 F
Machinability	Machine best at a hardness of about Rockwell C20		
Weldability	Can be welded by acetylene torch, metal arc, carbon arc and resistance methods		
CORROSION RESISTANCE	Resistant to atmospheric corrosion and to fresh and salt water		
AVAILABLE FORMS	Bar, plate, sheet, strip, wire, tubing, forgings, castings		
USES	Length standards, instruments, hypodermic syringes, textile machine parts, thermostatic bimetal — up to 400 F	Higher temperature thermostatic bimetal, instruments, glass sealing — up to 650 F	Higher temperature low expansion applications—up to 1000 F

*Balance iron.

Nickel-Base Superalloys—Cast, Wrought

Type ➡	Inconel X[a]	Hastelloy B[b]	Hastelloy C[b]	Hastelloy X,[b] Unitemp HX	René-41, R-41[c]
COMPOSITION, %	Cu 0.05, Cr 15.0, Fe 7.0, Al 0.75, Si 0.40, Ti 2.50, Mn 0.50, C 0.05, S 0.007, Cb 0.90, Ni bal	Co 2.50, Cr 1.0, Mo 26.0–30.0, Fe 4.0–7.0, Si 1.0, Mn 1.0, C 0.05, Ni bal	Co 2.50, Cr 14.5–16.5, Mo 15.0–17.0, W 3.0–4.5, Fe 4.0–7.0, Si 1.0, Mn 1.0, C 0.08, Ni bal	Co 0.5–2.5, Cr 20.5–23.0, Mo 8.0–10.0, W 0.20–1.0, Fe 17.0–20.0, C 0.05–0.15, Si 1.0, Mn 1.0, Ni bal	Cr 18.0–20.0, Co 10.0–12.0, Mo 9.0–10.5, Fe 5.0, C 0.09–0.12, Si 0.5, Mn 0.1, Ti 3.0–3.3, Al 1.4–1.6, Ni bal
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.30	0.33	0.32	0.30	0.30
Melting Temp Range, F	2540–2600	2408–2462	2318–2381	2350	—
Ther Cond (1100 F), Btu/hr/sq ft/°F/ft	13.0	9.5	9.9	12.0	11.7
Coef of Ther Exp (70–1600 F), per °F	9.2×10^{-6}	7.8×10^{-6}	8.2×10^{-6}	9.0×10^{-6}	8.7×10^{-6}
Specific Ht (70–212 F), Btu/lb/°F	0.10	0.09	0.09	0.10	0.11
Elec Res (75 F), microhm-cm	122	135	130	118.3	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi					
Room Temp	31×10^{6}	26.4×10^{6}	29.8×10^{6}	28.6×10^{6}	31.8×10^{6}
1000 F	25×10^{6}	29.6×10^{6}	24.8×10^{6}	24.3×10^{6}	27.2×10^{6}
1500 F	18.5×10^{6}	21.8×10^{6}	19.5×10^{6}	—	24.2×10^{6}
Ten Str, 1000 psi					
Room Temp	162	121	121	114	206
1000 F	140	101	99.3	94	203
1500 F	52	53 (1600 F)	56.4 (1600 F)	52	126
1800 F	9	21	31.7	22.5	58 (1700 F)
Yld Str (0.2% offset), 1000 psi					
Room Temp	92	56.5	57.8	52.2	154
1000 F	84	39.3	43.9	41.5	147
1500 F	44	35.8 (1600 F)	36.5 (1600 F)	37	118
1800 F	5.5	22.1	18.2	16	50 (1700 F)
Elong (in 2 in.), %					
Room Temp	24	63	47.5	43	14
1000 F	22	67	52	45	14
1500 F	22	22 (1600 F)	47 (1600 F)	33.5	14
1800 F	89	26	49	45	26 (1700 F)
Hardness, Brinell					
Room Temp	209	205[d]	241[d]	—	—
1000 F	—	156[d]	184[d]	—	—
Impact Str (Izod), ft-lb					
—320	33	53[d]	27[d]	—	—
Room Temp	37	58–62[d]	21–23[d]	—	—
Rupture Str (1500 F), 1000 psi					
10 Hr	38	26[f]	26[d]	22[d]	65[d]
100 Hr	28	16[f]	18[d]	14.5[d]	45[d]
1000 Hr	18	10[f]	12.5[d]	—	29[d]
THERMAL TREATMENT					
Solution Temp, F	2100 (2–4 hr, a.c.)	2150 (a.c.)	2250 (w.q.)	2150 (w.q.)	1950 (4 hr, a.c.) or 2150 (2 hr, a.c.)
Aging Temp, F	1550 (24 hr, a.c.) and 1330 (20 hr, a.c.)	—	—	—	1650 (4 hr, a.c.) or 1400 (16 hr, a.c.)
FABRICATING PROPERTIES					
Hot Working Temp, F	2225–1900	2175–1800	2250–1850	2200–1800	2150–1850
Machinability Index[e]	15	12	10	—	—
Weldability	Satisfactory	Good	Good	Excellent	Good
AVAILABLE FORMS	Sheet, rod, bar, shapes, tube, plate, wire	Sheet, strip, plate, bar, wire, tubing, electrodes, forgings; sand and investment castings	Sheet, strip, plate, bar, wire, tubing, electrodes, forgings; sand and investment castings	Sheet, plate, bar, wire, electrodes, forgings; sand and investment castings	Sheet, strip, plate, bar, forgings, wire; investment castings
USES	Jet engines, missiles, furnaces, etc., where high temperature corrosion resistance is vital				

[a] Hot rolled bar heat treated as specified unless otherwise indicated.
[b] Sheet 0.094 in. thick heat treated as specified unless otherwise indicated.
[c] Bar solution treated 4 hr at 1950 F, air cooled, aged 16 hr at 1400 F unless otherwise indicated.
[d] Heat treated bar.
[e] Based on AISI B1112 Steel = 100.
[f] Sheet aged 72 hr at 1700 F.

continued on next page

Nickel-Base Superalloys—Cast, Wrought

Type ➔	Udimet 500	Udimet 700	Waspaloy	Nicrotung[a]	J-1500
COMPOSITION, %	C 0.15 (max), Al 2.5–3.2, Ti 2.5–3.2, Mo 3.0–5.0, Cr 15.0–20.0, Co 13.0–20.0, Fe 4.0, B 0.008 (max), Ni bal	C 0.15 (max), Al 3.75–4.75, Ti 3.0–4.0, Mo 4.5–5.7, Cr 13.0–17.0, Co 17.0–20.0, Fe 1.0, B 0.10 (max), Ni bal	C 0.10 (max), Al 1.3, Ti 3.00, Mo 4.25, Cr 19.50, Co 13.5, Fe 2.0, B 0.005, Zr 0.085, Mn 0.50 (max), Si 0.75 (max), S 0.030 (max), Cu 0.10 (max), Ni bal	C 0.10, B 0.05, Zr 0.05, Cr 12.0, Co 10.0, W 8.0, Al 4.0, Ti 4.0, Ni bal	C 0.15, Cr 20.0, Co 10.0, Mo 10.0, Ti 3.0, Al 1.0, Ni bal
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.29	0.28	0.29	0.30	0.29
Ther Cond (1600 F), Btu/hr/sq ft/°F/ft	14.1	—	14.6	—	12.4[e]
Coef of Ther Exp (1800 F), per °F	9.8×10^{-6}	—	9.7×10^{-6}	8.8×10^{-6}	7.7×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	—	—
Elec Res (70–1800 F), microhm-cm	121.5–136.5	130–148	—	—	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi					
Room Temp	31.2×10^6	32.1×10^6	31.9×10^6	33.5×10^6	29.8×10^6
1500 F	23.3×10^6	23.5×10^6	24.1×10^6	25.7×10^6 [b]	21.8×10^6
1800 F	20.6×10^6	—	21.1×10^6	—	—
Ten Str, 1000 psi					
Room Temp	197	205	188	130	180
1200 F	175	180	165	120	168
1500 F	125	130	100	115	106
1800 F	46	52	55 (1700 F)	67	74 (1600 F)
Yld Str (0.2% offset), 1000 psi					
Room Temp	110	140	120	120	122
1200 F	110	125	105	111	108
1500 F	90	110	90	102	93
1800 F	35	45	50 (1700 F)	52	70 (1600 F)
Elong (in 2 in.), %					
Room Temp	18	16	29	5	16
1200 F	11	15	23	11	11
1500 F	20.5	33	28	4	13
1800 F	22	27	36 (1700 F)	6	18 (1600 F)
Hardness, Rockwell					
Room Temp	C37	—	C37	C38–40	C38
800 F	C36	—	C35	—	C33
1000 F	C36	—	C35	—	—
1200 F	C32	—	C35	—	C33
Fatigue Str (10^7 cycles, 1500 F), 1000 psi	48	49	40	37[c]	50[f]
Rupture Str (1600 F), 1000 psi					
100 Hr	32	42	25	48	23
1000 Hr	21	29	15	36[d]	14
THERMAL TREATMENT					
Solution Temp, F	2150 (2 hr, a.c.), 1975 (4 hr, a.c.)	2150 (4 hr, a.c.), 1975 (4 hr, a.c.)	1975 (4 hr, a.c.)	—	2100 (4 hr, a.c.), 1950 (4 hr, a.c.)
Aging Temp, F	1550 (24 hr, a.c.), 1400 (16 hr, a.c.)	1550 (24 hr, a.c.), 1400 (16 hr, a.c.)	1550 (24 hr, a.c.), 1400 (16 hr, a.c.)	—	1400 (16 hr, a.c.)
FABRICATING PROPERTIES					
Hot Work Temp, F	1900–2175	1875–2050	1850–2150	Not workable	1700–2100
Machinability	Satisfactory	Satisfactory	Satisfactory	—	—
Weldability	Satisfactory	Satisfactory	Satisfactory	—	Good
OXIDATION RESISTANCE	Excellent	Good	Good	Good	Good
AVAILABLE FORMS	Bar, billet, plate, sheet, strip	Bar, billet, plate	Bar, wire, billet, plate, sheet, strip	Casting alloy	Bar, plate, sheet, wire, forgings
USES	Jet engines, missiles, etc., where high temperature corrosion resistance is vital				

[a] Castings. [b] At 1600 F. [c] 10^8 cycles at 1700 F. [d] 500 hr. [e] From 70–1500 F. [f] 10^8 cycles.

Nickel-Base Superalloys—Cast, Wrought

Type ➡	Unitemp 1753	M-252	Inconel 700	Inconel 713C [a]
COMPOSITION, %	C 0.24, Mn 0.05, Si 0.10, Cr 16.25, Co 7.20, Mo 1.60, W 8.40, Ti 3.15, Al 1.90, Zr 0.06, B 0.008, Fe 9.50, Ni bal	C 0.16, Mn 0.02, Si 0.08, Cr 19.10, Co 9.95, Mo 9.70, Ti 2.55, Al 1.10, Zr 0.06, B 0.005, Fe 2.10, Ni bal	C 0.16, Mn 0.10, Si 0.25, Cr 15.0, Ti 2.20, Al 3.0, Co 28.0, Mo 3.0, Fe 0.7, Ni bal	C 0.14, Mn 0.25 max, Si 0.5 max, Cr 13.0, Mo 9.5, Ti 0.75, Al 6.0, Fe 2.5 max, Cb + Ta 2.3, Ni bal
PHYSICAL PROPERTIES				
Density, lb/cu in	0.305	0.298	0.295	0.286
Melting Temp Range, F	2525–2575	2470–2500	—	—
Ther Cond (1500 F), Btu/hr/sq ft/°F/ft	—	12.4	10.3	—
Coef of Ther Exp (80–1600 F), °F	8.2×10^{-6}	7.8×10^{-6}[e]	9.27×10^{-6}	8.3×10^{-6}
Elec Res, microhm-cm	132.0	—	—	—
MECHANICAL PROPERTIES[b]				
Mod of Elast in Tension, psi				
Room Temp	31.0×10^{6}	29.8×10^{6}	32.0×10^{6}	—
1000 F	26.5×10^{6}	26.0×10^{6}	27.7×10^{6}	—
1500 F	23.5×10^{6}[d]	21.8×10^{6}	24.0×10^{6}	—
Ten Str, 1000 psi				
Room Temp	194	175	170	121
1200 F	176	152	147	123
1600 F	90	71	84	106
Yld Str (0.2% offset), 1000 psi				
Room Temp	130	98	104	107
1200 F	127	92	92	101
1600 F	89 (1650 F)	71	56	83
Elongation (in 2 in.), %				
Room Temp	20	25.0	25.0	6.0
1200 F	16	35.5	23.0	8.0
1600 F	16	39.5	7.0	9.0
Red. of Area, %				
Room Temp	23	—	27.0	10.0
1200 F	20	27.0	37.0	16.0
1600 F	23	55.5	8.0	17.4
Fatigue Str (10^{8} cycles), 1000 psi				
1300 F	58 (1350 F)	60	—	—
1500 F	48	50	—	—
Rupture Str (1500 F), 1000 psi				
10 Hr	60	48	55	70
100 Hr	47	38	42	56
1000 Hr	34	23	31	43
FABRICATING PROPERTIES				
Hot Working Temp, F	1850–2150	1800–2150	—	—
Machinability[c]	Poor	Poor	8	6
Weldability	Limited data	Limited data	Weldable	Rarely welded
CORROSION RESISTANCE	Excellent res to jet engine gases up to 1600 F; very good res to salt spray. Good oxidation res under continuous operation up to 1900 F		Good corrosion and oxidation resistance up to 1600 F	Excellent res to oxidation up to 1900 F
AVAILABLE FORMS	Bar, billet, forgings, sheet, wire		Bar, forgings	Investment castings
USES	Jet engine turbine buckets, wheels; high temp bolts and fasteners; airframes		Aircraft engine blades and other high temp components	Aircraft gas turbine blades and vanes, and other high temp applications

[a] Casting alloy.
[b] Properties for materials in the following conditions:
Unitemp 1753: Bar solution treated 4 hr at 2150 F, air cooled, aged 16 hr at 1400 F, air cooled.
M-252: solution treated 4 hr at 1950 F, air cooled, aged 15 hr at 1400 F, air cooled.
Inconel 700. rod solution treated 2 hr at 2160 F, air cooled, aged 4 hr at 1600 F, air cooled.
Inconel 713C: as cast bar.
[c] Based on AISI B1112 steel = 100. [d] 1600 F. [e] 70–1500 F.

Precious Metals—Wrought

Metal →	Gold[a]	Silver[b]	Platinum[c]	Palladium[b]
PHYSICAL PROPERTIES				
Density, lb/cu in	0.698	0.379	0.775	0.434
Melting Point, F	1945	1761	3224	2829
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	172	242	42	41
Coef of Ther Exp (32-212 F), per °F	7.9×10^{-6}	10.9×10^{-6}	4.9×10^{-6}	6.5×10^{-6}[d]
Spec Ht, Btu/lb/°F	0.031	0.056	0.031	0.058
Elec Res (32 F), microhm-cm	2.35	1.59[d]	14.9	10.8[d]
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	12×10^6	11×10^6	21×10^6	17×10^6
Ten Str, 1000 psi				
Annealed	19	22	17-26	30
Cold Worked	32[e]	54[f]	34-45	47
As Cast	18	15	—	—
Yld Str, 1000 psi				
Annealed	Nil	8	2-5.5	5
Cold Worked	30	44	27	30
As Cast	—	5	—	—
Elong (in 2 in.), %				
Annealed	45	48	30-40	24-40
Cold Worked	4	2.5	2.5-3.5	1.5
As Cast	30	60	—	—
Red. of Area (as cast), %	—	67	—	—
Hardness (Brinell)				
Annealed	25	25-35	38-52	46
Cold Worked	58	—	97-13	109
As Cast	33	42	—	—
Endurance Limit (10^7 cycles, annealed), 1000 psi	4.6	—	—	—
FABRICATING PROPERTIES				
Annealing Temp, F	—	400-600	1475-2200	1475
Hot Working Temp Range, F	Any to melting point	—	1475-2300	1475-2300
Max Red. Between Anneals, %	Apparently unlimited	—	99	99
Casting Temp Range, F	2000-2370	2000	3300	3000
Joining	Braze with silver solder, no flux, any flame. Can be resistance welded by any method. Oxyacetylene weld with no flux, any flame	Braze with silver solder. Can be resistance welded	Braze with fine gold or white platinum solder. Hammer weld at 1800 F. Can be resistance or oxyacetylene welded	Braze with oxyacetylene torch using platinum solders. Can be resistance welded
CORROSION RESISTANCE	Does not oxidize when heated in air. Resists alkalis, salts and most acids. Not attacked by oxygen or sulfur. Rapidly attacked by chlorine and bromine	Does not oxidize when heated in air. Resists most dilute mineral acids and alkalis. Attacked rapidly by nitric and hot sulfuric acids. Attacked rapidly by sulfur-bearing gases	Does not oxidize when heated in air. Resists reducing or oxidizing acids alone but is dissolved by aqua regia	Oxidizes when heated in air. Resists hydrofluoric, acetic and phosphoric acids. Attacked by nitric, sulfuric and hydrochloric acids; and bromine and iodine
AVAILABLE FORMS	Foil, rod, wire, sheet, tubing	Sheet, strip, rod, wire, tubing	Foil, sheet, wire, tubing	Sheet, foil, wire, tubing
USES	Lining of chemical equipment, high melting solder, alloys for electrical and chemical purposes, jewelry, dentistry	Electrical contacts, corrosion resisting equipment, bearings, photography supplies; alloying for coinage, brazing alloys, jewelry	Chemical equipment, electrical contacts, catalysts, laboratory equipment, jewelry	Electrical contacts, catalysts, production of pure hydrogen, jewelry, dental alloys

[a]Gold is generally produced in three grades: proof gold, 99.99% Au; refined gold, 99.95-99.98% Au; and 99.5% Au, which is accepted by the U.S. Mint without penalty.
[b]Usually refined to "the high purity suitable for general use"; in some cases spectographically pure.
[c]Platinum is produced in four grades: type A, 99.99% Pt, sometimes called physically pure; type B, 99.9% Pt, sometimes called chemically pure; type C, 99.5% Pt (crucible grade); and type D, 99% Pt (commercial platinum).
[d]68 F. [e]Cold rolled, 60% reduction. [f]Cold rolled, 50% reduction.

Precious Metals—Cast, Wrought

Metal →	Rhodium[b]	Ruthenium[b]	Osmium[b]	Iridium[b]
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.447	0.441	0.82	0.813
Melting Point, F	3571	4530	4890	4450
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	50	—	—	34
Coef of Ther Exp (68 F), per °F	4.6×10^{-6}	5.1×10^{-6}	3.6×10^{-6}	3.8×10^{-6}
Specific Heat, Btu/lb/°F	0.059	0.057	0.031	0.031
Elec Res (68 F), microhm-cm	4.51	7.6[g]	9.5	5.3
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	42×10^{6}	60×10^{6}	80×10^{6}	74×10^{6}
Ten Str, 1000 psi				
Annealed	73	—	—	—
Cold Worked	300	—	—	—
Hardness (Brinell)				
Annealed	55-156	—	—	170
Cold Worked	260-390	—	—	350
As Cast	—	220	350	163
FABRICATING PROPERTIES				
Hot Working Temp Range, F	1900-2000	2700-4300	Not workable	2200-2700
Max Red. Between Anneals, %	30-40	—	—	—
Casting Temp, F	3700	4700	5000	4600
Joining	Can be brazed and resistance welded	Can be brazed and resistance welded	Can be brazed and resistance welded	Can be brazed and resistance welded
CORROSION RESISTANCE	Oxidizes slowly when heated in air. Resistant to most acids, including aqua regia at room temperature	Oxidizes when heated in air. Unattacked by common acids, including aqua regia up to 212 F. Moderately attacked by solutions of alkaline hypochlorites	Oxidizes rapidly in air at elevated temperatures. Resists common acids at room temperatures, but is attacked by aqua regia	Oxidizes slowly when heated in air. Unattacked by common acids, including aqua regia up to 212 F
AVAILABLE FORMS	Powder, sheet, wire	Powder	Cast or sintered parts	Sheet, wire, rod, powder
USES	Mirrors and electrodeposits for a nontarnishing finish; alloys with platinum and palladium for crucibles, glass-working equipment, catalysts, spinnerets	Hardener for platinum and palladium	Alloys used for pen tips, phonograph needles, electrical contacts, instrument pivots	Extrusion dies for glass, alloys with platinum for electrical contacts, fuse wires, hypodermic needles, jewelry

[b] Usually refined to "the high purity suitable for general use"; in some cases spectrographically pure.
[g] At 32 F.

Tin and Its Alloys—Cast, Wrought

Type ➔	Grade A Tin	Hard Tin	Tin Foil	White Metal	Pewter
COMPOSITION, %	Sn 99.8 min	Sn 99.6, Cu 0.4	Sn 92, Zn 8	Sn 92, Sb 8	Sn 91, Sb 7, Cu 2
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.264	—	—	0.262	0.263
Melting Temp Range, F	449.4	441–446	390	475	471–563
Ther Cond (77 F), Btu/hr/sq ft/°F/ft	37	—	34	—	—
Coef of Ther Exp (32–212 F), per °F	13×10^{-6}	—	—	—	—
Spec Ht, Btu/lb/°F	0.054	—	—	—	—
Elec Res (68 F), microhm-cm	11.5	—	12	15	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	$6\text{–}6.5 \times 10^6$	—	—	—	7.7×10^6
Ten Str, 1000 psi					
Annealed Sheet	2.2	3.3	—	6.7	8.6
Cold Rolled Sheet	2.8	4.0	8.7	7.4[b]	7.6
As Cast	2.1	—	—	7.2[c]	—
Yld Str, 1000 psi					
Annealed Sheet	1.3	—	—	—	—
Cold Rolled Sheet	2.0	—	6.0	—	—
As Cast	1.7	—	—	—	—
Elong (in 2 in.), %					
Annealed Sheet	45	—	—	70	40
Cold Rolled Sheet	35	—	40	28[b]	50
As Cast	55[a]	—	—	—	—
Hardness (Brinell)					
Annealed Sheet	7	—	—	17	13[d,f]
Cold Rolled Sheet	8	—	—	—	18[e,f]
As Cast	5–6	—	—	20[c]	23[d,f]
Impact Str (Izod, as cast), ft-lb	14	—	—	22[c]	—
Endurance Limit (as cast), 1000 psi	0.34	—	—	—	—
FABRICATING PROPERTIES					
Casting Temp Range (chill), F	525–550	525–550	—	575–600	600–625
Joining	Bonds easily by simple melting. Eutectic tin-lead solder or low melting fusible alloys might be used on massive parts such as block tin pipe		—	Readily soldered	Can be soldered with some of the fusible alloys
CORROSION RESISTANCE	Resists distilled, sea and soft tap water. Attacked by strong acids, alkalis and acid salts. Oxygen in solution accelerates rate of attack		—	—	Tarnishes in soft water; suffers localized attack at water line in hard water. Attacked by dilute hydrochloric and citric acids in presence of air
AVAILABLE FORMS	Sheet, pipe, foil, castings, powder	Tubing, foil	Foil	Castings, sheet	Castings, sheet
USES	Linings for food cans; pipe for handling water, beer, and carbonated beverages; linings for food processing equipment, food wrappings	Collapsible tubes, foil	Foil for wrapping food, medicines, electrical condensers	Rubber mold castings, cast and wrought costume jewelry	Mountings and ornamental objects such as tea and coffee services, vases and book ends

[a] In 4 in.
[b] Sheet quenched from 425 F.
[c] Chill cast.
[d] Vickers pyramid hardness.
[e] Vickers pyramid hardness after heat treating 8 hr at 300 F.
[f] Hardenable pewter values are: 18, 28, 29, respectively.

Tin-Lead-Antimony Alloys—Cast

Grade[a] →	1[b]	2	3	4	5[c]
COMPOSITION, %	Sn 91, Sb 4.5, Cu 4.5	Sn 89, Sb 7.5, Cu 3.5	Sn 84, Sb 8, Cu 8	Sn 75, Pb 10, Sb 12, Cu 3	Sn 65, Pb 18, Sb 15, Cu 2
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.265	0.267	0.269	0.272	0.280
Melting Temp Range, F	433–700	466–669	464–792	363–583	358–565
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	7.3×10^6	7.6×10^6	—	—	—
Ten Str, 1000 psi					
Chill Cast	9.3	11	10–12	—	—
Die Cast	10.3	—	—	—	11.8
Elong (in 2 in., die cast), %	22	—	—	—	4
Hardness (Brinell)					
Chill Cast	17	24	27	25	22
Die Cast	—	—	—	—	27.7
Impact Str (Izod, chill cast), ft-lb	2.5	—	1	—	—
Endur Limit (chill cast), 1000 psi	3.8[d]	4.8[d]	—	—	—
Compr Str (chill cast, 25% set), 1000 psi	13	15	18	16	15
Compr Yld Str (chill cast, 0.125% set), 1000 psi	4.4	6.1	6.6	5.5	5.0
FABRICATING PROPERTIES					
Casting Temp Range (chill), F	750–825	795	850–915	710	690–700
CORROSION RESISTANCE	Resists oxidation products of lubricants; food products, beer and carbonated beverages	Resist oxidation products of lubricants			
AVAILABLE FORMS	Precision inserts of babbitt-lined strip, lined bearing shells, ingots, die castings			Ingots	Ingots, die castings
USES	Bearings, die castings for dairy machinery, dental appliances, surgical instruments, soda fountain equipment	Most widely used tin-base bearing alloy in automotive field	High load applications, hardest of standard tin babbitts and has greatest load carrying capacity	Limited bearing applications	Limited bearing applications Die cast parts

[a] ASTM B23-49.
[b] Also die casting Alloy 1, ASTM B102-48.
[c] Also die casting Alloy 8, ASTM B102-48.
[d] 2×10^7 cycles.

continued on next page

Tin-Lead-Antimony Alloys—Cast

Grade[a] →	6	7	8	10	11
COMPOSITION, %	Sn 20, Sb 15, Pb 63.5, Cu 1.5	Sn 10, Sb 15, Pb 75	Sn 5, Sb 15, Pb 80	Sn 2, Sb 15, Pb 83	Sb 15, Pb 85
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.336	0.350	0.361	0.362	0.370
Melting Temp Range, F	358-531	464-514	459-522	468-507	471-504
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	—	14	14	—	—
Coef of Ther Exp (68-212 F), per °F	—	10.9×10^{-6}	13×10^{-6}	—	—
Spec Ht, Btu/lb/°F	—	0.065	0.065	—	—
Elec Res (68 F), microhm-cm	—	28.6	28.2	—	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	—	4.2×10^{6}	4.2×10^{6}	—	—
Ten Str, 1000 psi[e]	—	10.5	10	—	6.8
Elong (in 2 in.), %[e]	—	4	5	—	8
Hardness (Brinell)[e]	21	22	20	18	15
Endurance Limit, 1000 psi[e]	—	4[d]	3.9[d]	—	—
Compr Str (25% deformation), 1000 psi[e]	14.5	15.6	15.6	15.4	12.8
Compr Yld Str (0.125% set), 1000 psi[e]	3.8	3.6	3.4	3.4	3.0
FABRICATING PROPERTIES					
Casting Temp (chill), F	655	640	645	630	630
CORROSION RESISTANCE	Resistant to corrosion by the usual lubricants				
AVAILABLE FORMS	Small ingots and bars				
USES[f]	General purpose bearing applications	General purpose bearings under moderate loads	Bearings for light loads and moderate speeds. Mining machinery, transmission machinery, car journals	Bearings for light loads and speeds. Blowers, pumps, electric motors, machine tools	Bearings for light loads

[a]ASTM B23-49.
[d]2×10^{7} cycles.
[e]Chill cast.
[f]Light loads—under 1000 psi; moderate loads—1000 to 2000 psi; heavy loads—over 3000 psi. Surface speeds: low—to 10 fps; moderate—to 20 fps; high—above 30 fps.

Tin-Lead-Antimony Alloys—Cast

Grade[a] →	12	15	16	19
COMPOSITION, %	Sb 10, Pb 90	Sn 1, Sb 15, Cu 0.5, As 1.0, Pb bal	Sn 10, Sb 12.5, Cu 0.5, Pb bal	Sn 5, Sb 9, Pb bal
PHYSICAL PROPERTIES				
Density, lb/cu in	0.384	0.362	0.355	0.378
Melting Temp Range, F	473-498	479-538	471-495	462-495
Coef of Ther Exp (68–212 F), per °F	14.6×10^{-6}	—	—	—
Specific Heat, Btu/lb/°F	0.065	—	—	0.065
Elec Res (68 F), microhm-cm	25.6	—	—	28.7
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	—	4.2×10^6	—	4.2×10^6
Tensile Strength, 1000 psi[e]	—	10.4	—	10
Elongation (in 2 in.), %[e]	—	2	—	5
Hardness (Brinell)[e]	14	21	28	18
Endurance Limit, 1000 psi[e]	—	4.3[d]	—	3.7[f]
Compressive Strength (25% deformation), 1000 psi[e]	12.9	—	—	15.6
Compressive Yield Strength (0.125% set), 1000 psi[e]	2.8	—	—	—
FABRICATING PROPERTIES				
Casting Temp (chill), F	625	660	620	620
CORROSION RESISTANCE	Resistant to corrosion by the usual lubricants			
AVAILABLE FORMS	Small ingots and bars			
USES[f]	Bearings for light loads	Bearings for high loads and speeds. Diesel engines, automotive engines, steamships, various types of machines	Bearings for moderate loads and speeds	Bearings for light loads and speeds. Car journal bearings

[a]ASTM B23–49.
[e]Chill cast.
[f]Light loads—under 1000 psi; moderate loads—1000 to 2000 psi; heavy loads—over 3000 psi. Surface speeds: low—to 10 fps; moderate—to 20 fps; high—above 30 fps. 2×10^7 cycles.

Titanium and Its Alloys—Wrought

Type →	Unalloyed	5 Al–2.5 Sn	8 Mn	3 Mn–1.5 Al	4 Mn–4 Al
COMPOSITION, %	Ti 99.0	Al 5.0, Sn 2.5	Mn 8.0	Al 1.5, Mn 3.0	Al 4.0, Mn 4.0
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.163	0.161	0.171	0.168	0.163
Melting Temp Range, F	3135	2822–3002	2730–2970	—	2822–3002
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	9.8	4.85	6.7	—	4.5
Coef of Ther Exp (68–1650 F), per °F	5.8×10^{-6}	5.7×10^{-6}	7.1×10^{-6}	—	5.7×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.125	0.127	0.118	—	0.129
Elec Res (68 F), microhm-cm	55.0	157.3	90.7	—	146.1
Magnetic Permeability (20 oersteds)	1.00005	1.00005	1.00005	—	1.00005
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension, psi	$15\text{–}16 \times 10^6$	$16\text{–}17.5 \times 10^6$	$15.5\text{–}17.5 \times 10^6$	15×10^6	$15.5\text{–}17.5 \times 10^6$
Ten Str, 1000 psi	80–110	115–145	120–150	125	140–170
Yld Str, 1000 psi	70–95	110–135	110–140	116	130–160
Elong (in 2 in.), %	15–25	10–20	10–20	18	10–20
Red. of Area, %	30–45	20–40	20–40	—	20–40
Hardness (Rockwell)	—	C30–35	C28–34	C26–32	C32–38
Impact Str (Charpy), ft-lb	20–35	15–25	—	15–20	11–15
Endurance Limit, 1000 psi					
Sheet (unnotched)	60–70	95	90	—	—
Bar (unnotched)	60–70	—	—	—	85–95
Bar (notched)	35–45	—	—	—	32[f]
Compr Yld Str, 1000 psi	75–100	115–140	115–145	—	—
Mod of Rigidity, psi	5.6×10^6	—	6×10^6	—	6.27×10^6
THERMAL TREATMENT					
Annealing Temp, F	850–1250	1500–1600	1300	1250	1300
Stress Relieving Temp, F	700–1000	1000–1200	<700 or at 1000	—	1000
FABRICATING PROPERTIES					
Hot Working Temp Range, F	300–800	800–1200	500–600	—	—
Forging Temp, F	1300–1600	1400–1900	—	1300–1700	1300–1750
Fusion Weldability[d]	Yes	Yes	No	Marginable	Questionable
Formability (sheet, 78 F)[e]	High	Intermediate	Good	Moderate	Bar only
Bend Radius (105° V)	3T	4.5T	3.5T	—	—
CORROSION RESISTANCE	Superior resistance to nitric acid, moist chlorine, chlorine solutions, chlorinated organic compounds, and inorganic chloride solutions. Excellent resistance to corrosive attack by sea water and most chloride salt solutions—unchallenged by other structural metals. Resists impingement, pitting attack				
AVAILABLE FORMS	Sheet, strip, plate, tubing, billets, bar, wire, foil	Sheet, strip, plate, wire, bar, billet	Sheet, strip, plate	Sheet, plate, billets, bar, wire	Billets, bar, forgings, plate, wire
USES	Aircraft and missile parts requiring corrosion resistance and high strength-to-weight ratio up to 800 F. Naval and marine applications; chemical, pharmaceutical and food processing and handling equipment; marine diesel engine mufflers; springs (high proportional limit and low modulus of elasticity), rivets, bolts, nuts, screws and fittings; ordnance and sporting equipment; orthopedic and orthodontic equipment; anodes				

[a] Annealed condition unless otherwise stated.
[d] Some users report difficulty in producing welds without porosity; others do not.
[e] All titanium sheet is formed with considerably less difficulty at elevated temperatures. Forming can be accomplished at temperatures in the 500 to 1000 F range with no need for postforming surface treatment, provided time at temperature is short.
[f] k = 3.9.

Titanium and Its Alloys—Wrought

Type ➔	7 Al–4 Mo	16 V–2.5 Al	4 Al–3 Mo–1 V	13 V–11 Cr–3 Al	6 Al–4 V
COMPOSITION, %	Al 7.0, Mo 4.0	V 16.0, Al 2.5	Al 4.0, Mo 3.0, V 1.0	V 13.0, Cr 11.0, Al 3.0	Al 5.5–6.3, V 3.5–4.5
PHYSICAL PROPERTIES					
Density, lb/cu in	0.162	0.168	0.161	0.175	0.160
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	4.1	—	—	4.3	4.3
Coef of Ther Exp (68–1650 F), per °F	4.9×10^{-6} [f]	—	—	5.2×10^{-6} [f]	5.8×10^{-6}
Spec Ht (212 F), Btu/lb/°F	0.123(68 F)	—	—	0.128	0.135
Elec Res (68 F), microhm-cm	175	—	—	—	176
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension (200 F), psi	$15.5–17.5 \times 10^6$	15×10^6	$15–17 \times 10^6$	$13–15 \times 10^6$	$15–17 \times 10^6$
Ten Str (68 F), 1000 psi					
Annealed	145–170	110–115	140	125–150	130–155
Heat Treated	160–200	175–1[illegible]0	190	190–240	170
Yld Str (68 F), 1000 psi					
Annealed	135–160	40–55	90	120–145	120–150
Heat Treated	150–190	160–165	168	170–220	150
Elong (in 2 in.), %					
Annealed (68 F)	10–18	15–20	16	10–20	10–20
Heat Treated	5–12	6–10	8	3–10	7–12
Red. of Area (68 F), %					
Annealed	20–40	65	—	20–40	25–40
Heat Treated	10–25	35	—	—	20–35
Hardness (Rockwell)					
Annealed	32–38	—	—	—	C30–36
Heat Treated	—	—	—	—	—
Impact Str (Charpy, 68 F), ft-lb	10–20	—	—	—	15–25
Endurance Limit (10^7 cycles), 1000 psi					
Bar (unnotched)	93	—	—	—	75
Bar (notched)	29	—	—	—	30
Sheet (notched)	—	—	—	34	—
Shear Str, 1000 psi	104–115	—	—	—	—
THERMAL TREATMENT					
Annealing Temp, F	1450–1650	—	1500–1675	1450	1350
FABRICATING PROPERTIES					
Hot Working Temp Range, F	—	—	—	200–400	—
Forging Temp, F	1400–1850	—	—	1800–1850	1450–1750
Fusion Weldability[d]	No	—	Limited	Yes	Marginal
Formability (sheet, 78 F)[e]	—	High	High	High	Intermediate
Bend Radius (105° V)	—	—	3.5T	3.5T	5.0T
CORROSION RESISTANCE	Superior resistance to nitric acid, moist chlorine, chlorine solutions, chlorinated organic compounds and inorganic chloride solutions Excellent resistance to sea water and most chloride salt solutions unchallenged by other structural metals Resist impingement, pitting attack				
AVAILABLE FORMS	Bar, rod, forgings, plate, wire, billet	Sheet, bar	Sheet, strip, plate	Sheet, strip, wire, bar, billet, foil	Bar, sheet, strip, billet, plate, wire
USES	Aircraft and missile parts requiring corrosion resistance and high strength-to-weight ratio up to 800 F. Naval and marine applications; chemical, pharmaceutical and food processing and handling equipment; marine diesel engine mufflers; springs (high proportional limit and low modulus of elasticity), rivets, bolts, nuts, screws and fittings; ordnance and sporting equipment; orthopedic and orthodontic equipment; anodes				

[a] Annealed condition unless otherwise stated. [b] 60-deg notch, 0.010-in radius, k = 2.7. [c] k = 4.0.
[d] Some users report difficulty in producing welds without porosity; others do not.
[e] All titanium sheet is formed with considerably less difficulty at elevated temperatures. Forming can be accomplished at temperatures in the 500 to 1000 F range with no need for postforming surface treatment, provided time at temperature is short.
[f] 68-200 F.

Zinc Alloys—Wrought

Type →	Commercial Rolled Zinc (deep drawing)	Commercial Rolled Zinc	Commercial Rolled Zinc (higher Pb, Cd)	Copper Hardened Rolled Zinc Alloy	Rolled Zinc Alloy (Cu, Mg)	Rolled Zinc Alloy (Cu, Ti)
COMPOSITION, %	Pb 0.10 max, Zn bal	Pb 0.05–0.10, Cd 0.05–0.08, Zn bal	Pb 0.25–0.50, Cd 0.25–0.45, Zn bal	Cu 0.85–1.25, Zn bal	Cu 0.85–1.25, Mg 0.006–0.016, Zn bal	Cu 0.50–1.5, Ti 0.12–0.50, Zn bal
PHYSICAL PROPERTIES						
Density, lb/cu in.	0.258	0.258	0.258	0.259	0.259	0.259
Melting Point, F	786	786	786	792	792	792
Ther Cond (64 F), Btu/hr/sq ft/°F/ft	62.2	62.2	—	—	60.5	60.5
Coef of Ther Exp, per °F						
With Grain	18.1×10^{-6}	18.1×10^{-6}	18.8×10^{-6}	—	19.3×10^{-6}	13.8×10^{-6}
Across Grain	12.8×10^{-6}	12.8×10^{-6}	13.0×10^{-6}	—	11.7×10^{-6}	10.8×10^{-6}
Spec Ht (68–212 F), Btu/lb/°F	0.094	0.094	0.094	0.0957	0.0957	0.0957
Elec Res (68 F), microhm-cm						
Hot Rolled	6.06	—	—	6.22	6.31	6.24
Cold Rolled	6.10	—	—	—	—	—
MECHANICAL PROPERTIES[a]						
Ten Str, 1000 psi						
Hot Rolled	19.5, 23	21, 25	23, 29	24, 30	29, 40	32, 42
Cold Rolled	21, 27	22, 29	25, 31	31, 40	36, 46	29, 37
Elong (in 2 in.), %						
Hot Rolled	65, 50	52, 30	50, 32	50, 35	20, 10	38, 21
Cold Rolled	50, 40	40, 30	45, 28	44, 30	25, 10	44, 60
Hardness (Brinell)						
Hot Rolled	38	43	47	52	61	—
Endurance Limit (hot rolled), 1000 psi	2.5	3.8	4.1	6.1	6.8	—
Creep Rate (12,000 psi, 77 F), days/%						
Hot Rolled	—	—	—	0.15	—	115.0
FABRICATING PROPERTIES						
Hot Working Temp Range F	248–527	248–527	248–437	447–572	447–572	382–572
Melting Range, F	887–977	887–977	887–977	887–977	887–977	887–977
Ingot Casting Range, F	815–905	815–905	815–905	815–905	815–905	815–905
Annealing Temp, F	—	—	221	347	347	482
Machinability	Good	Good	Good	Good	Good	Good
Joining						
Torch Welding	Poor to fair	Poor to fair	Poor to fair	Poor to fair	Poor to fair	Good
Single Impulse Resistance Welding	Poor	Poor	Poor	Poor	Poor	Good
Multiple Impulse Resistance Welding	Fair to good	Fair to good	Fair to good	Fair to good	Fair to good	Good
Soldering	Good	Good	Good	Good	Good	Good
Common Processes	Drawing, bending, roll forming, stamping, swaging, coining, extruding					
	Impact extrusion					
	Spinning					
CORROSION RESISTANCE	Excellent resistance to both metropolitan and rural atmospheric corrosion (penetration in in. per yr is 0.000064 in Palmerton, Pa., and 0.00028 in New York City); also hot soapy water, printing inks, trichloroethylene, carbon tetrachloride, dry illuminating gas, and moisture- and acid-free hydrocarbons. Fair resistance to pure ethyl and methyl alcohols, glycerine, water, petroleum products. Poor resistance to steam, spray insecticides, animal oils, strong acids and bases, and mixtures of glycerine or alcohol and water					
AVAILABLE FORMS	Rolled plate, strip and sheet; extruded rod and shapes; drawn rod and wire					
USES	Dry batteries, eyelets and grommets, address plates, flashing, weatherstrip, laundry tags, novelties. lithoplates, condenser cans, embossing tape, leaders and gutters, corrugated roofing					
	Parts requiring no rigidity	Parts requiring some rigidity		Parts requiring maximum rigidity	Parts requiring maximum rigidity and some creep resistance	Parts requiring maximum rigidity and creep strength; low thermal expansion; resistance to grain growth

[a] Two values represent properties parallel to grain and perpendicular to grain, in that order.

Zinc Alloys—Cast

Type ➔	Alloy XXIII[a]	Alloy XXV[a]	Slush Casting Alloy[b]	Slush Casting Alloy (unbreakable metal)[b]
COMPOSITION, %	Al 3.5–4.3, Mg 0.03–0.08, Zn[c] bal	Al 3.5–4.3, Cu 0.75–1.25, Mg 0.03–0.08, Zn[c] bal	Al 4.5–5.0, Cu 0.2–0.3, Zn[c] bal	Al 5.25–5.75, Zn[c] bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.24	0.24	—	—
Melting Point, F	728	727	734	743
Ther Cond (158–284 F), Btu/hr/sq ft/°F/ft	65.3	62.9	—	—
Coef of Ther Exp (68–212 F), per °F	15.2×10^{-6}	15.2×10^{-6}	—	—
Spec Ht (68–212 F), Btu/lb/°F	0.10	0.10	—	—
Elec Res (68 F), microhm-cm	6.37	6.54	—	—
MECHANICAL PROPERTIES[d]				
Ten Str, 1000 psi				
Die Cast	41	47.6	—	—
Chill Cast	—	—	28.0	25.0
Elong (in 2 in.), %				
Die Cast	10	7	—	—
Chill Cast	—	—	—	1
Hardness (Brinell, die cast)	82	91	—	—
Impact Str (Charpy), ft-lb				
Die Cast	43	48	—	—
Chill Cast	—	—	3	1
Endurance Limit (10^8 cycles, die cast), 1000 psi	6.9	8.2	—	—
Compr Yld Str (die cast), 1000 psi	60	87	—	—
Shear Str (die cast), 1000 psi	31	38	—	—
FABRICATING PROPERTIES				
Melting Temp Range, F	728–932	727–932	—	—
Die Casting Temp Range, F	740–800	740–800	—	—
Solidification Shrinkage, %	1.17	1.17	—	—
Machinability	Good	Good	Good	Good
Joining				
Torch Welding	Poor to fair	Poor to fair	—	—
Single Impulse Resistance Welding	Poor	Poor	—	—
Multiple Impulse Resistance Welding	Fair to good	Fair to good	—	—
Soldering	Poor[e]	Poor[e]	—	—
Common Fabrication Processes	Welding, soldering, machining, riveting, spinning, cold swaging		Welding, soldering, machining	
CORROSION RESISTANCE	Excellent resistance to both metropolitan and rural atmospheric corrosion[f]; also hot soapy water, printing inks, trichloroethylene, carbon tetrachloride, dry illuminating gas, and moisture- and acid-free hydrocarbons. Fair resistance to pure ethyl and methyl alcohols, glycerine, water and petroleum products. Poor resistance to steam, spray insecticides, animal oils, strong acids and bases, and mixtures of glycerine or alcohol and water			
USES	Automotive parts, household utensils, office equipment, building hardware, padlocks, toys, novelties, drop hammer dies (XXV)		Slush and permanent mold castings, principally for lighting fixtures	

[a] ASTM B86-57T.
[b] Because of their limited use, few data are available on these alloys.
[c] Special high grade zinc is required.
[d] Based on a ¼-in. section for die cast alloys; a ½-in. section for chill cast alloys.
[e] Cadmium-zinc and lead-tin solders diffuse into the casting, promoting subsurface attack. Castings must be nickel plated to be joined by lead-tin solders.
[f] Penetration in in. per yr in Palmerton, Pa., and New York City, respectively, is 0.78×10^{-4} and 2.2×10^{-4} for XXIII, and 0.63×10^{-4} and 2.8×10^{-4} for XXV.

Hafnium, Thorium, Uranium, Vanadium, Beryllium—Wrought

Metal →	Hafnium	Thorium	Uranium	Vanadium	Beryllium
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.47	0.42	0.69	0.23	0.067
Melting Point, F	3400	3180	2071	3110	2341
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	—	21.4[c]	14.5[c]	—	87
Coef of Ther Exp (70 F), per °F	3.4×10^{-6}	6.2×10^{-6}	12.1×10^{-6}[e]	4.8×10^{-6}	6.4×10^{-6}
Spec Ht, Btu/lb/°F	0.035	0.03	0.03	0.12	0.45
Elec Res (68 F), microhm-cm	30[a]	18	25–50	25	5
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	20×10^{6}	10×10^{6}	30×10^{6}	20×10^{6}	44×10^{6}
Ten Str, 1000 psi					
Annealed	77	34	90	72	60–90[f]
Cold Worked	112[b]	49[d]	—	113	—
Yld Str, 1000 psi					
Annealed	32	26	25	64	45–55[f]
Cold Worked	96[b]	45[d]	—	109	—
Elong (in 2 in.), %					
Annealed	24	51	13	28	2–5[f]
Cold Worked	10[b]	—	—	3	—
Hardness (Rockwell)					
Annealed	A58	—	—	B81	—
Cold Worked	A65[b]	—	—	B93	—
FABRICATING PROPERTIES					
Annealing Temperature, F	1380 in vacuum or inert atm	1380 in vacuum	—	1650 in vacuum or inert atm	1400–2100 in vacuum[g]
Workability	Can be hot worked at 1550 F; cold worked 30% between anneals	Can be readily hot or cold worked; fabricated by forging, rolling, swaging, extruding or drawing	Can be forged, rolled, swaged and drawn; heating must be done in a protective atm	Good cold working properties	Hot worked at 750–1800 F
Machinability	Similar to stainless steel	Can be machined like mild steel with or without cutting fluids	Moderately difficult to machine	Tools similar to those for cold rolled steel	Difficult because of low ductility
Joining	—	Difficult to weld; brazing yields brittle joints	Can be welded or brazed in protective atm or vacuum	Can be welded with heliarc torch under argon	Brazed with aluminum alloy or silver alloy rods
CORROSION RESISTANCE	Resistant to oxidizing acids but attacked by hydrofluoric acid	Very poor resistance to atmosphere, water and most reagents	Very poor resistance to atmosphere, water and most reagents	Resists sea water; not affected by moderate strength hydrochloric and sulfuric acids; dissolved by any strength nitric acid	Resists atm at ambient temp; attacked by oxygen and nitrogen at elevated temp; resists sea water; attack in fresh water varies with air content
AVAILABLE FORMS	Has been produced in sheet and rod	Has been produced in rod, sheet, thin-walled tube, fine wire, foil	Has been produced in plate, rod, tube, wire and foil	Plate, strip, bar, sheet, wire	Sheet, plate, rod, bar, tube, powder
USES	Nuclear reactors	Secondary (breeder) reactor fuel	Fissionable material (fuel) in nuclear reactor	AEC applications	Nuclear reactors, missiles, aircraft

[a] 32 F. [b] 20% cold work. [c] 70 F [d] 50% cold work. [e] 70–250 F, parallel to A axis; 0.8×10^{-6} parallel to B axis; 12.9×10^{-6} parallel to C axis. [f] Warm extruded and annealed at 1400 F. Mechanical properties greatly influenced by method of fabrication. [g] Depends on form.

Zirconium and Its Alloys—Wrought

Type →	Commercial Grade[a]	Reactor Grade	Zircaloy-2[b]	ATR
COMPOSITION, %	Hf 2.0, Zr bal	Hf 0.001 max, Zr bal	Sn 1.5, Fe 0.12, Cr 0.10, Ni 0.05, Zr bal	Cu 0.5, Mo 0.5, Zr bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.237	0.235	0.237	0.24
Melting Point, F	3350	3350	3300	3300
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	—	9.6	8.1	—
Coef of Ther Exp (212 F), per °F	3.1×10^{-6}	3.1×10^{-6}	3.6×10^{-6}	—
Specific Heat, Btu/lb/°F	—	0.067	—	—
Elec Res, microhm-cm	40	40	74	—
MECHANICAL PROPERTIES				
Modulus of Elasticity, psi	14×10^6	14×10^6	13.8×10^6	14×10^6
Tensile Strength (annealed), 1000 psi				
Room Temperature	64	49	68	—
600 F	30	19	30	45
Yield Strength (0.2% offset; annealed), 1000 psi				
Room Temperature	53	29	61	—
600 F	23	10	21	42
Elongation (in 2 in.; annealed), %				
Room Temperature	24	32	37	—
600 F	35	52	35	24
Reduction of Area (annealed), %				
Room Temperature	42	40	45	—
600 F	65	—	60	—
Hardness (Rockwell)	B89	B70	B89	B84
FABRICATING PROPERTIES				
Annealing Temperature, F[c]	1200–1450	1200–1400	1200–1400	1000–1500
Workability	Zirconium is very ductile and workable and can be fabricated with standard shop equipment (with a few modifications and special techniques, e.g., those used for titanium). Hot working range is 1400–1750 F. Minimum sheet bend radius is 3–5T			
Joining	May be welded under inert atmosphere; can be brazed and soldered			
CORROSION RESISTANCE	Excellent resistance to hydrochloric and nitric acids in all concentrations and temperatures (up to boiling); resists sulphuric acid (up to 55%) to its boiling point; resists alkalis at all concentrations and temperatures. Attacked by hydrofluoric acid and Aqua Regia		Excellent resistance to steam and pressurized water up to 550 F	Excellent resistance to wet and dry carbon dioxide up to 1000 F
AVAILABLE FORMS	Ingot, billet, rod, bar, sheet, strip, tube, and wire. Pipe, fittings, castings, and shapes available on request			
USES	Chemical plant equipment	Fuel cladding and structural parts in nuclear reactors; flash bulb filler	Fuel cladding and structural parts in water or steam cooled nuclear reactors	Structural parts in gas-cooled nuclear reactors

[a] Another grade (containing 500 ppm Fe + Cr) is available for severe service in hot hydrochloric acid.
[b] A similar grade, Zircaloy-4 (Sn 1.5, Fe 0.20, Cr 0.10), picks up less hydrogen in reactor service.
[c] Light gage material or finish machined parts should be annealed in a vacuum to prevent surface oxidation.

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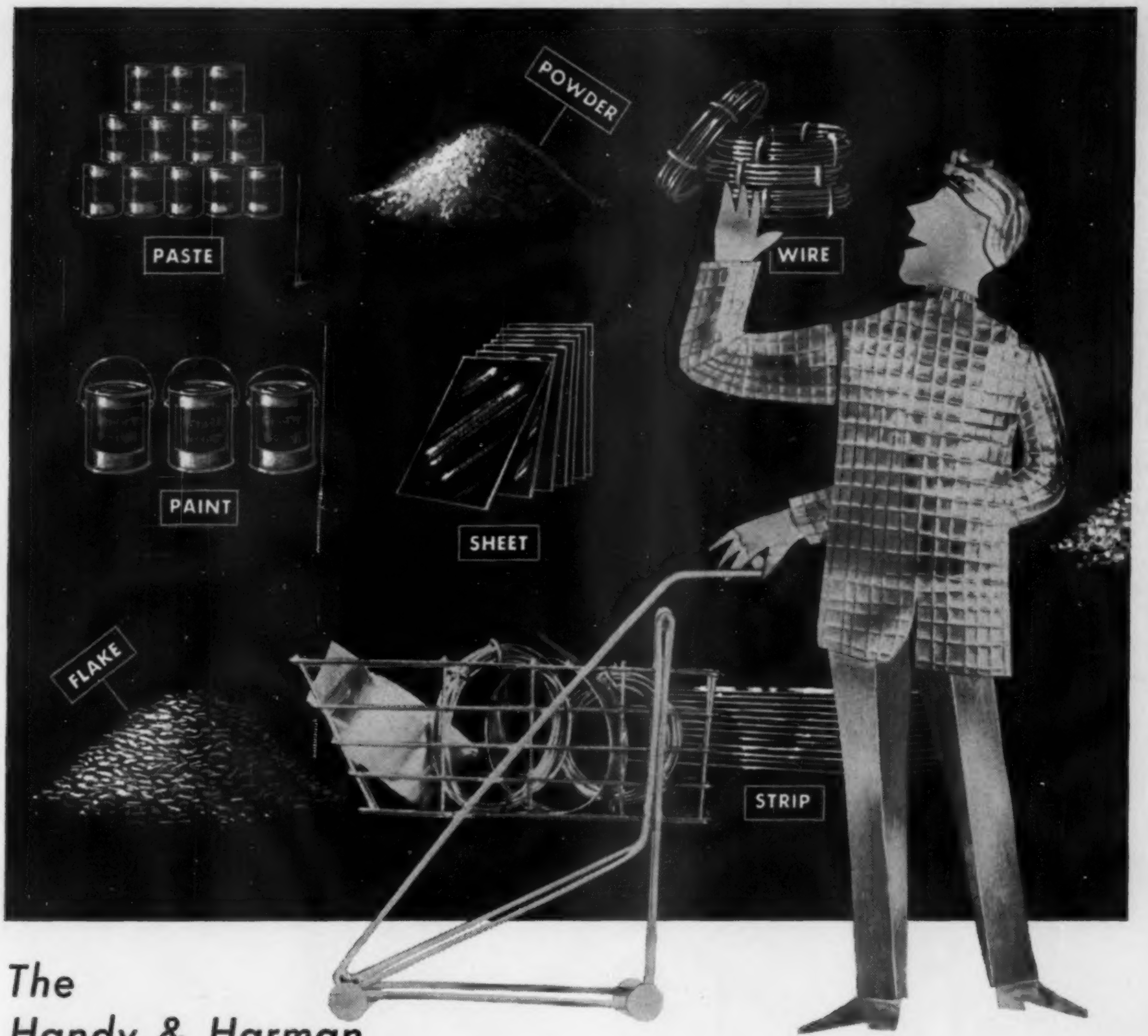

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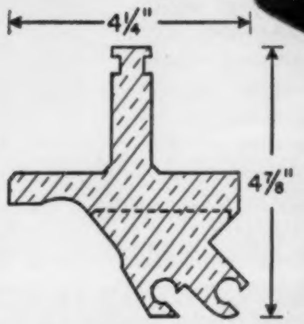
AGAIN-



DOTTED LINE SHOWS where two copper extrusions were brazed together to make original part. When you consider the intricate shape and the weight of the part (a 3$\frac{7}{16}$" section measuring 4¼" x 4⅞", weighing 8 lbs. 7 ozs.), you can readily understand why it was at first thought impractical to make it into a single extrusion.

Revere helps "fit the metal to the job"

AND ONE COPPER EXTRUSION REPLACES TWO, SAVING TIME AND MONEY WITH CONSIDERABLE INCREASE IN LIFE OF PART

The Revere Copper Extrusion shown above was originally two extrusions brazed together. And, since it is quite an intricate shape, and weighty, it was at first thought impractical to make as a single extrusion, but the possibility was believed to be worth investigating.

Through close collaboration between the manufacturer's engineering department and the Revere Methods and Production Departments, it was found possible to combine these two sections into a single extrusion. Work was started, dies were made and test runs conducted. The tooling (for hot extrusion was followed by cold drawing) posed special problems. It had to be both rugged and precise in order to produce this monster to the manufacturer's exacting specifications. Finally, a sample extrusion was delivered to the customer for testing and found to be right in every way.

Not only does this new, single extrusion eliminate a great deal of machining but obviates the necessity of purchasing two separate extrusions and brazing them together. This means substantial savings in dollars and time involved, plus a longer-lasting part, because the heat required to join the two pieces originally used, tended to soften the built-up unit, thus shortening its useful life.

So, before you give up on what at first may seem an insoluble problem, why not call in Revere's Technical Advisory Service? It's entirely possible they can help you "fit the metal to the job" with a resultant saving in the production of a superior product.

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COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

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Distributors Everywhere.

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For high strength without excessive weight, the designer of this heavy truck chose Tenzaloy for the front engine supporting frame.

TENZALOY

Why TENZALOY is the most widely used high-strength aluminum casting alloy

Among high-strength, self-aging aluminum casting alloys, Tenzaloy has won greatest acceptance and widest use by designers because of its unique all-round combination of properties. Outstanding among these special qualities are:

- High yield and tensile strength, combined with adequate ductility
- Exceptional machinability
- Remarkable dimensional stability
- High impact, shock resistance

When Tenzaloy is specified, one big problem is eliminated: heat treatment. Without any artificial thermal treatment, Tenzaloy castings will precipitation-harden at room temperature to give properties normally obtainable only by the expensive solution treating, quenching, and artificial aging of the heat-treatable alloys.

Here are typical properties for Federated Tenzaloy:

Tensile strength	35,000 psi
Yield strength	25,000 psi
Elongation (in 2 in.)	4-5%
Brinell hardness No.	74
Impact strength (Charpy in ft.-lbs.):	
Notched	3
Un-notched	14
Electrical conductivity	30%

Tenzaloy also is corrosion resistant, has superior ductility, and is easily anodized, dyed and polished to brilliant decorative finishes. Castability is excellent in green sand, plaster, investment, shell, oil-bonded sand and precision molds of all kinds. No special techniques are required for handling Tenzaloy in the foundry. Since Tenzaloy has mechanical properties equivalent to such common heat-treated alloys as 195T6, 355T6, 356T6 and 319T6, it can be substituted in applications where any of these heat-treated alloys are presently used.

It is particularly suited to high-strength designs where load carrying capacity and impact strength are essential. For example: frames, brackets, levers, bases, housings, missile ground handling equipment, jet aircraft turntables, explosion-proof enclosures, heavy-duty wheel hubs and cable drums, to name a representative few.

Tenzaloy can widen your design possibilities, increase production efficiency, improve your products, reduce costs. Get complete facts on its physical and mechanical properties by writing for Bulletin No. 103 R5 to: Federated Metals Division, American Smelting and Refining Company, 120 Broadway, New York 5, N. Y.

ASARCO

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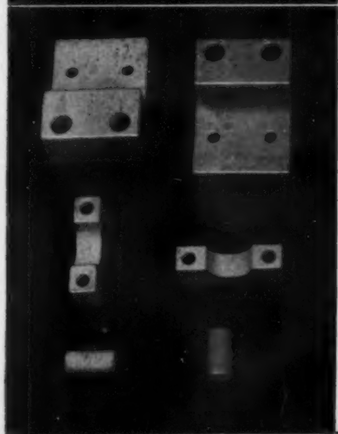
BERYLLIUM COPPER. BERYLCO alloys extend the performance possibilities of metal parts. Available in easy-to-fabricate strip, wire, rod, billets, forgings, castings, casting ingots, and master alloys.

Typical Properties

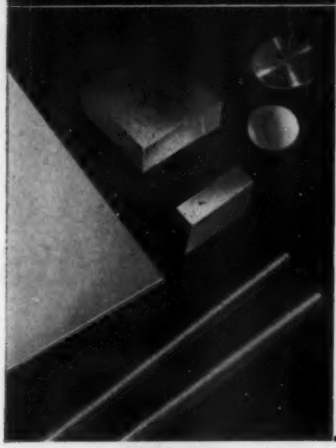
Ultimate Tensile Strength	up to 200,000 psi
Hardness	up to Rockwell C45
Non-Magnetic	permeability of 1.002 max.
Modulus of Elasticity	19,000,000 psi
Endurance Strength	45,000 psi
Electrical and Thermal Conductivity	up to 55% IACS
Age Hardenable	Can be worked soft, and precipitation hardened for maximum properties
Resists anelastic behavior	



BERYLLIUM OXIDE. This high temperature material is making possible new advances in nuclear, electronic, and the aircraft/missile fields. Its high dielectric strength, good electrical resistance, high thermal conductivity, and low neutron cross section give BERYLCO beryllium oxide a valuable "blend" of performance characteristics.

Typical Properties

Specific Gravity	3.008
Maximum Use Temperature	4000°F
Modulus of Rupture @ 70°F	26,000 psi
Thermal Conductivity, $\frac{\text{BTU-inch}}{\text{HR x SQ. FT. x °F}}$	
@ 70°F	1885
@ 392°F	1105
Electrical Volume Resistivity, Ohm-inch	
@ 70°F	1×10^{13}
@ 392°F	1×10^{12}
Loss Factor @ 1 mc	0.0008
Dielectric Strength	≧250 v/mil
Thermal Neutron Absorption Cross Section	0.00074 cm^2/cm^3



BERYLLIUM METAL. Structurals and components of BERYLCO beryllium are now doing key jobs that could never be performed before. Its unusual combination of properties is earning for beryllium an increasing importance in a wide range of applications. Available in sheet, rod, block extrusions and forgings.

Typical Properties

Melting Point	1285°C (2345°F)
Density (gm/cc)	1.85 (.066 lb./in.^{3})
Elastic Modulus, psi	42,000,000
Ultimate Tensile Strength, psi	40,000 hot pressed 70,000 extruded
Yield Strength, psi	30,000 hot pressed 45,000 extruded

ALSO AVAILABLE: Beryllium Nickel, Beryllium Aluminum, Beryllium Magnesium, Ferro-Beryllium

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Refractory Metals Warehouse LIST OF STANDARD STOCK ITEMS

TANTALUM

TANTALUM FOIL

0.00055 x 12 x Coil
.001 x 12 x Coil
.002 x 12 x Coil
.003 x 12 x Coil
.004 x 12 x Coil

TANTALUM SHEET

0.005 x 12 x R/L	.040 x 12 x 42
.007 x 12 x R/L	.050 x 12 x 34
.010 x 12 x 84	.060 x 12 x 28
.013 x 12 x 72	.090 x 12 x 28
.015 x 12 x 56	.125 x 12 x 28
.020 x 12 x 84	.187 x 18 x 30
.025 x 12 x 66	.250 x 18 x 25
.030 x 12 x 54	

TANTALUM WIRE AND ROD

0.003 x 200 M/Spool	.094 x Coil
.005 x 150 M/Spool	.125 x R/L
.007 x 135 M/Spool	.187 x R/L
.010 x 150 M/Spool	.250 x R/L
.015 x 75 M/Spool	.312 x R/L
.020 x 40 M/Spool	.375 x R/L
.025 x 25 M/Spool	.500 x R/L
.031 x 15 M/Spool	.625 x R/L
.040 x Coil	.750 x R/L
.050 x Coil	1.000 x R/L
.062 x Coil	1.250 x R/L

TANTALUM HEXAGON BAR

0.375 x R/L
.500 x R/L
.625 x R/L

TANTALUM THREADED ROD

(Q-14208)—10-32 x 24
(Q-14326)—12-28 x 12
(Q-14189)—¼-28 x 12

TANTALUM SEAMLESS TUBING

0.125 OD x 0.010 Wall	.500 OD x .020
.125 OD x .015	.625 OD x .015
.187 OD x .015	.625 OD x .020
.250 OD x .010	.750 OD x .015
.250 OD x .015	.750 OD x .020
.250 OD x .020	1.000 OD x .020
.375 OD x .010	1.250 OD x .020
.375 OD x .015	1.500 OD x .020
.375 OD x .020	2.000 OD x .020
.500 OD x .010	
.500 OD x .015	

TANTALUM ORIFICE TUBES

0.120 ID x 0.150 OD x ½ Lg.
.210 ID x .240 OD x ¾ Lg.

TANTALUM HEX NUTS

(Q-11648-2) —10-32
(Q-12560-2B)—12-28
(Q-12561-2A)—¼-28
(Q-14430-2A)—5/16-24
(Q-14431-2A)—⅜-24
(Q-14432-2A)—½-20

TANTALUM SCREWS

(Q-10585-B) 10-32 x ¾ Filister Head

TANTALUM STUDS

(Q-12596) 10-32 x ⅞
(Q-12774A) 10-32 x ¾
(Q-12932) 12-28 x 1

TANTALUM RIVETS

(Q-10103) .052 Dia. x .067 Lg.
(Q-10180A) .052 Dia. x .124 Lg.
(Q-10197-3) .090 Dia. x .187 Lg.
(Q-10197-4) .090 Dia. x .250 Lg.

TANTALUM CUPS

(Q-14439)—.495 ID x .010 Wall x .490 Deep

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Tapered Condenser
3" x 2" x 36" (D-4562)
6" x 2" x 60" (D-4538)
8" x 4" x 60" (D-4570)
Single Tube Bayonet Htr. 1" Dia. Tube x 18" (F-20580-4)
Htr. 1½" Dia. Tube x 30" (F-20580-5)
Htr. 1½" Dia. Tube x 48" (F-20580-6)
Htr. 1½" Dia. Tube x 60" (F-20580-7)
Three Tube Bayonet Htr. 1½" Dia. Tubes x 69" (F-20807-1E)
Pilot Plant (D-4514)

TUNGSTEN

TUNGSTEN SHEET

0.005 x 8 x 18	.030 x 12 x 14
.007 x 8 x 18	.040 x 13 x 13
.010 x 11 x 18	.060 x 18 x 18
.015 x 9 x 23	.090 x 10 x 9
.020 x 9 x 18	.100 x 18 x 18
	.125 x 18 x 18

TUNGSTEN WIRE AND ROD

0.125 Diameter	0.312 Diameter
.156 Diameter	.375 Diameter
.187 Diameter	.500 Diameter
.250 Diameter	.750 Diameter

TUNGSTEN BOATS

(Q-12466-1)—5/16 Wide x 3/16 Deep x 1¾ Long Cavity

FANSTEEL 77 METAL

FANSTEEL 77 METAL RODS

¼ Diameter	1 Diameter
½ Diameter	1¼ Diameter
⅝ Diameter	1½ Diameter
¾ Diameter	

MOLYBDENUM

MOLYBDENUM FOIL

0.0005 x 6 x Coil	.003 x 6 x Coil
.001 x 6 x Coil	.004 x 6 x Coil
.002 x 6 x Coil	

MOLYBDENUM SHEET

0.005 x 12 x 30	.040 x 12 x 48
.007 x 12 x 30	.050 x 12 x 36
.010 x 12 x 45	.060 x 12 x 54
.015 x 12 x 56	.090 x 12 x 42
.020 x 12 x 72	.125 x 12 x 30
.025 x 12 x 66	.187 x 12 x 27
.030 x 12 x 56	.250 x 12 x 19

MOLYBDENUM NICKEL PLATED SHEET

0.005 x 6 x 25, Plated 2 Sides
.010 x 6 x 25, Plated 2 Sides
.015 x 6 x 25, Plated 2 Sides
.015 x 6 x 25, Plated 1 Side
.020 x 6 x 25, Plated 2 Sides
.020 x 6 x 25, Plated 1 Side
.040 x 6 x 25, Plated 2 Sides
.040 x 6 x 25, Plated 1 Side

MOLYBDENUM WIRE AND ROD

0.020 x Coil	.187 x R
.025 x Coil	.250 x R
.031 x Coil	.312 x R
.040 x Coil	.375 x R
.050 x Coil	.500 x R
.062 x Coil	.625 x R
.094 x Coil	.750 x R
.125 x R	

MOLYBDENUM ELECTRODES

1.000 Diameter
1.250 Diameter
1.500 Diameter

MOLYBDENUM SEAMLESS TUBING

0.125 OD x 0.016 Wall	½ OD x .030
.187 OD x .020	⅝ OD x .040
.250 OD x .020	¾ OD x .050
.250 OD x .030	⅞ OD x .070
.312 OD x .030	1 OD x .100
.375 OD x .040	
.437 OD x .050	
.500 OD x .060	

MOLYBDENUM FABRICATED PARTS

(H-8735-B) Drawn Boat
1⅛ Wide x ¾ Deep x 8½ Long
(Q-14791) Crucible
2 21/32 OD x 1 3/16 Deep
(Q-14792) Crucible
2 13/32 OD x 1 21/32 Deep
(Q-14793) Crucible
1 61/64 OD x 2⅛ Deep
(Q-14794) Crucible
1½ OD x 2 11/16 Deep
(Q-41024) Rivets
.050 Dia. x .143 Long, .094 Head Dia.
(Q-40144) Rivets
.053 Dia. x .125 Long, .104 Head Dia.
(Q-12367-3) Rivets
.093 Dia. x .187 Long, .187 Head Dia.
(Q-12367-5) Rivets
.093 Dia. x .250 Long, .187 Head Dia.
(Q-12369-8) Rivets
.187 Dia. x .750 Long, .312 Head Dia.
(Q-12368-10) Rivets
.125 Dia. x .375 Long, .250 Head Dia.

COLUMBIUM

COLUMBIUM FOIL

0.001 x RW x RL
.002 x RW x RL
.005 x RW x RL

COLUMBIUM SHEET

0.010 x RW x RL
.015 x RW x RL
.020 x RW x RL
.060 x RW x RL

COLUMBIUM ALLOYS

FANSTEEL 80 METAL SHEET (Cb-Zr)

0.005 x RW x RL
.015 x RW x RL

FANSTEEL 82 METAL SHEET (Cb-Ta-Zr)

0.010 x RW x RL
.020 x RW x RL
.040 x RW x RL
.060 x RW x RL
.080 x RW x RL

All Dimensions in Inches, Unless Otherwise Indicated

FANSTEEL

METALLURGICAL CORPORATION

Mill products. Fansteel provides quick service for special items not included in warehouse stocks. Larger sheet sizes, special tubing, rod, foil, etc., are produced in one of the world's largest and most complete plant facilities for handling refractory metals. For information on specific items, write direct, or consult your Fansteel Sales Engineer.

Capacitor-grade tantalum in foil, powder, sheet and wire is produced by the Chemical and Metallurgical Division right from the ore. Controlled production methods produce tantalum with superior electrical properties. In foil, Fansteel supplies high reliability as well as standard grades. Fansteel tantalum powder is graded double-capacitance for its ability to provide increased capacity without increasing the anode size.

Ingots and powder in tungsten, molybdenum, tantalum and columbium are supplied by Fansteel for a range of applications including missile and rocket hardware. This hydrostatic press is one of the largest commercial presses in the U.S. Its pressure chamber measures 18-inches in diameter and is 5-foot deep. Fansteel supplies refractory metal powders in a range of particle sizes and mesh fractions.

Sources of Data

Many of the compilations in this issue are entirely new. Collecting new data and up-dating old compilations required the aid of many organizations. Although it would be impractical to list all who contributed in one way or another, we acknowledge particularly the assistance of the following:

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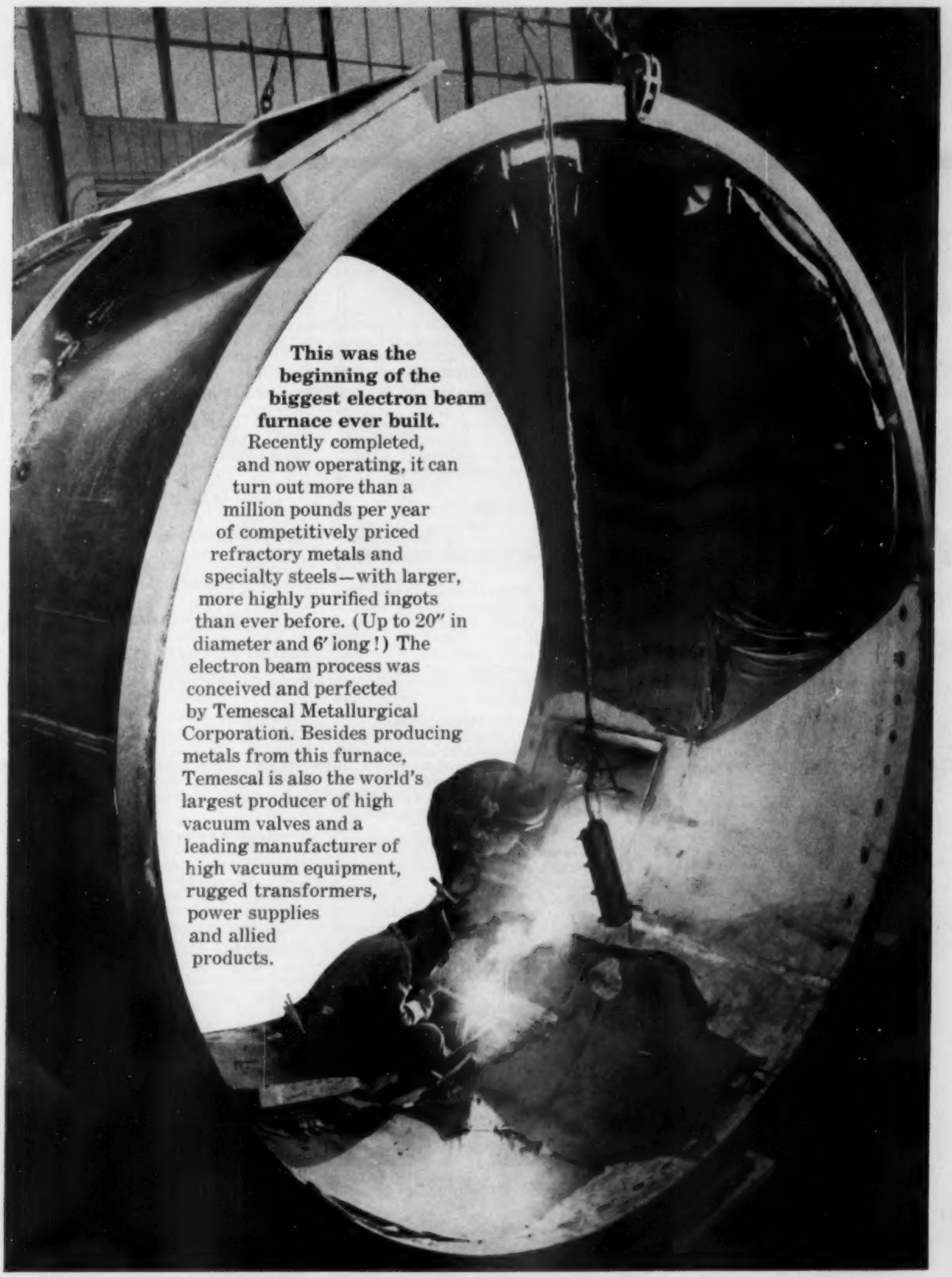

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PLASTICS AND RUBBER

Plastics Compounds. Allied Chemical Corp., Plastics Div., 10 pp. Briefly outlines characteristics and applications of melamine, urea, alkyd and nylon molding compounds, and polyester and phenolic resins. **70**

Polypropylene. AviSun Corp., 12 pp, illus. Physical, mechanical, and thermal properties; grades available; typical uses; comparative costs; and information on design of molded polypropylene parts. **71**

ABS Plastics. Marbon Chemical Div., Borg-Warner Corp., 8 pp, illus., No. 10240-561. Advantages; characteristics; uses; physical, mechanical, thermal, and electrical properties; and other information on ABS plastics. **72**

Plastics Materials. Celanese Corp. of America, Celanese Polymer Co. Div. General descriptions; physical, chemical, electrical and mechanical properties; and typical applications of high density polyethylene, cellulose proprionate, cellulose acetate, and polyester resins. **73**

Hardener for Epoxy Resins. Ciba Products Corp., 10 pp, illus., No. 25. Typical properties, applications, pot life and curing cycles of a safety hardener for epoxy resins. **74**

Plastic Products. Dow Chemical Co., 12 pp, illus., No. 150-5-60. Formulations, characteristics, properties, and uses of this company's entire line of plastics materials. Includes monomers, latexes, resins, molding and extrusion materials, foamed products, film and sheeting, and building products. **75**

Plastics Films. E. I. du Pont de Nemours & Co., Inc., Film Dept., 8 pp, illus., No. A-12703. Advantages, characteristics, properties, and typical uses of several industrial plastics films, including polyester, polyvinyl fluoride, polyethylene, fluorocarbon, cellophane, and acetate. **76**

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Butyl Rubber. Enjay Chemical Co., Div. of Humble Oil & Refining Co., 12 pp, illus., No. 2d/En. Weather, sunlight, chemical, solvent and heat resistance; electrical properties; and uses of butyl rubber. **78**

Polypropylene. Enjay Chemical Co., Div. of Humble Oil & Refining Co. Advantages, characteristics, properties, uses, and other information on polypropylene. **79**

Plastics Properties. Fiberite Corp. Comparative chart for compression molders and transfer molders lists mechanical, electrical and thermal properties of all general purpose thermosetting plastics materials. **100**

Synthetic Latex. Firestone Tire & Rubber Co., Synthetic Rubber & Latex Co. Div., 8 pp, illus. Properties of hot and cold type synthetic rubber latices. **101**

Diallyl Phthalate. Food Machinery & Chemical Corp., Chemicals & Plastics Div., Dapon Dept., 25 pp, No. 18. Properties; uses; molding procedures; and electrical, chemical, thermal, and mechanical properties of diallyl phthalate molding compounds. **80**

Industrial Plastics. Garlock, Inc., 16 pp, illus., No. AD-177. Specifications, advantages, properties, typical uses, and other information on stock shapes and molded and fabricated parts made of TFE, CFE, acetal, nylon and other industrial plastics. **81**

Polycarbonate Resins. General Electric Co., Chemical & Metallurgical Div., Chemical Materials Dept., 4 pp, illus., No. CDC-389. Lists sources of polycarbonate resins and standard fabricated shapes, including rod, sheet, tube, film, and slab. Includes available sizes, outstanding characteristics, and properties. **82**

Polyester Resins. Glidden Co., Paint & Varnish Div. Information on the advantages and applications of polyester resins. **83**

Vinyl Resins. B. F. Goodrich Chemical Co., 24 pp, No. G-15. Information on the preparation and application of vinyl solution resins for coating metal, wood, paper, fiberboard, and rubber. Includes a list of properties and a discussion of appication procedures. **84**

Plastics Catalog. Hooker Chemical Corp., Durez Plastics Div., 8 pp, illus., No. D400. Physical, mechanical and electrical properties; and typical applications of phenolic and diallyl phthalate molding compounds; phenolic bonding and coating resins; and fire-retardant polyester resins for reinforced plastics and molded shapes. **85**

Epoxy Compounds. Hysol Corp., 10 pp, illus. General information and typical uses of epoxy compounds for adhesives and sealants, tooling materials, and electrical insulation. **102**

Plastics Packaging Suppliers. Koppers Co., Inc., Plastics Div., 3 pp, No. C-10-211. A directory of both custom and proprietary plastics packaging molders and extruders. Includes type of service company is equipped to provide and the names of the company's officers. **103**

Diallyl Phthalate. Mesa Plastics Co., 2 pp. Data on the corrosion resistance of nine different formulations of diallyl phthalate molding compounds. **86**

Styrene-Acrylonitrile. Monsanto Chemical Co., Plastics Div. Tensile and impact properties of styrene-acrylonitrile copolymer and styrene-acrylonitrile-butadiene terpolymer are compared with those of several other plastics materials. **87**

ABS Plastics. O'Sullivan Rubber Corp., 6 pp, illus. Properties, advantages, characteristics, colors, patterns, typical uses, fabricability, and other information on ABS plastics. **88**

Vinylidene Fluoride Resin. Pennsalt Chemicals Corp., 16 pp, illus., No. VF2R60. Chemistry, properties, typical uses, resin forms, chemical resistance, fabrication data, and other information on a vinylidene fluoride resin. **89**

Phenolics. Plastics Engineering Co., 16 pp, illus. General information on phenolic molding compounds, including available colors, range of properties and typical advantages and applications. **90**

Filled Nylon. Polymer Corp., Molding Resins Div., 4 pp, illus., No. GS-2. Series of case histories illustrate advantages and characteristics of a molybdenum disulfide-filled nylon molding compound. Included is a chart of physical properties. **91**

Fluorocarbon Plastics. Raybestos-Manhattan, Inc., Plastics Products Div., 36 pp, illus., No. 9703. Properties, design data, tolerances, and descriptions of a number of different uses for fluorocarbon plastics, resins, tubing, tapes and molded products. **92**

Reinforced Plastics. Raybestos-Manhattan, Inc., Reinforced Plas-

More literature on page 276

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PLASTICS AND RUBBER

Acrylics—Cast, Molded, Extruded

Type ➔		Cast Resin Sheets, Rods		Moldings	
		General Purpose Type I[a]	General Purpose Type II[a]	Grades 5, 6, 8[b]	High Impact Grade
PHYSICAL PROPERTIES	**ASTM**				
Specific Gravity	D792	1.17–1.19	1.18–1.20	1.18–1.19	1.12–1.16
Ther Cond, Btu/hr/sq ft/°F/ft	[c]	0.12	0.12	0.12	0.12
Coef of Ther Exp, 10^{-5} per °F	D696	4.5	4.5	3–4	4–6
Spec Ht, Btu/lb/°F		0.35	0.35	0.35	0.34
Refractive Index	D542	1.485–1.500	1.485–1.495	1.489–1.493	—
Transmittance (luminous, 0.125 in.), %	D791	91–92	91–92	>92	—
Haze, %	D672	1–2	1–2	<3	—
Water Absorption (24 hr), %	D570	0.3–0.4	0.2–0.4	0.3–0.4	0.2–0.3
Flammability (0.125 in.), ipm	D635	0.5–2.2	0.5–1.8	0.9–1.2	0.8–1.2
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638	3.5–4.5	4.0–5.0	3.5–5.0	2.3–3.3
Ten Str, 1000 psi	D638	6–9	8–10	9.5–10.5	5.5–8.0
Elong (in 2 in.), %	D638	2–7	2–7	3–5	>25
Hardness (Rockwell)	D785	M80–90	M96–102	M80–103	L60–94
Impact Str (Izod notched), ft-lb/in.	D256	0.4	0.4	0.2–0.4	0.8–2.3
Mod of Elast in Flex, 10^5 psi	D790	3.5–4.5	4.0–5.0	3.5–5.0	2.8–3.6
Flex Str, 1000 psi	D790	12–14	15–17	15–16	8.7–12.0
Compr Yld Str (0.1% offset), 1000 psi	D695	12–14	14–18	14.5–17	7.3–12.0
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	$>10^{15}$	$>10^{15}$	$>10^{14}$	2.0×10^{16}
Dielec Str (short time), v/mil	D149	450–530	450–500	400	400–500
Dielec Const					
60 Cycles	D150	3.5–4.5	3.5–4.5	3.5–3.9	3.5–3.9
10^6 Cycles	D150	2.7–3.2	2.7–3.2	2.7–2.9	2.5–3.0
Dissip Factor					
60 Cycles	D150	0.05–0.06	0.05–0.06	0.04–0.06	0.03–0.04
10^6 Cycles	D150	0.02–0.03	0.02–0.03	0.02–0.03	0.01–0.02
Arc Resistance, sec		No track	No track	No track	No track
FABRICATING PROPERTIES					
Bulk Factor		—	—	1.8–2.2	—
Injection Molding					
Pressure, 1000 psi		—	—	10–20	10–20
Temperature, F		—	—	320–500	400–490
Hot Forming Temp, F		250–320	280–340	240–350	—
Extruding Temp, F		—	—	350–450	—
HEAT RESISTANCE					
Max Rec Svc Temp, F		140–160	180–200	155–190	—
Heat Dist Temp, F		150–180	190–225	166–202[d]	169–205
CHEMICAL RESISTANCE		Resist weak alkalis, acids and aliphatic hydrocarbons. Attacked by esters, ketones, aromatic hydrocarbons, chlorinated hydrocarbons and concentrated acids			
USES		Transparent aircraft enclosures, radio and television parts, lighting, drafting equipment, signs		Decorative and functional automotive parts, reflectors, protective goggle lenses, radio and television parts, household appliance parts	Shoe heels, control knobs, business machine and piano keys, pump parts, sprinkler heads, tool handles

[a] ASTM D702.
[b] Range includes typical values for Grades 5, 6, and 8, and may be superior to minimum or maximum requirements for these grades as detailed in ASTM D788.
[c] Conco-Fitch.
[d] D788 specified values for Grades 5, 6, and 8: 149 F, 162 F, 183 F respectively.

Alkyds—Molded

Type →	ASTM	Granular (general purpose)	Putty (electrical)	Glass-Reinforced (impact)
PHYSICAL PROPERTIES				
Specific Gravity	D792	2.22–2.24	2.05–2.15	2.00–2.08
Ther Cond, Btu/hr/sq ft/°F/ft		0.35–0.60	0.35–0.60	0.20–0.30
Coef of Ther Exp, per °F	D696	$1–3 \times 10^{-6}$	$1–3 \times 10^{-6}$	$1–3 \times 10^{-6}$
Water Absorption (24 hr), %	D570	0.08–0.10	0.05–0.08	0.07–0.10
Flammability, ipm	D635	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES				
Tensile Strength, 1000 psi	D651	3–4	3–4	6–10
Impact Strength (Izod notched), ft-lb/in.	D256	0.30–0.35	0.30–0.35	8–12
Mod of Elast in Flexure, psi	D790	$22–27 \times 10^5$	$22–27 \times 10^5$	$22–28 \times 10^5$
Flexural Strength, 1000 psi	D790	7–10	7–10	14–17
Compressive Strength, 1000 psi	D690	16–20	18–20	24–28
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257	10^{14}	10^{14}	10^{14}
Dielectric Strength (step by step), v/mil	D149	300–350	300–350	300–350
Dielectric Constant				
60 Cycles	D150	6.0–6.5	6.0–6.5	5.2–6.0
10^6 Cycles	D150	4.8–5.0	4.2–4.5	4.0–4.5
Dissipation Factor				
60 Cycles	D150	0.050–0.060	0.035–0.040	0.02–0.03
10^6 Cycles	D150	0.016–0.018	0.014–0.015	0.017–0.022
FABRICATING PROPERTIES				
Bulk Factor	D954	1.95–2.15	1.1–1.2	9–11
Compression Molding				
Pressure, 1000 psi		1.0–1.5	0.8–1.0	1.5–2.0
Temperature, F		270–330	270–330	270–330
HEAT RESISTANCE				
Max Rec Svc Temp (limited periods), F		350	300	350
Heat Dist Temp (264 psi), F	D648	350–400	350–400	>400
CHEMICAL RESISTANCE		Resistant to weak acids; attacked by alkalis; practically unattacked by organic liquids such as alcohols, hydrocarbons and fatty acids		
USES		Ignition parts, fuse blocks, switch and circuit breaker covers and bases, molded resistors and capacitors, television tuner segments		

Cellulose Acetate—Molded, Extruded

Type →	ASTM	Type I —Medium[a]	Type II—Hard[a] H6	Type II—Hard[a] H4	Type II—Hard[a] H2	Type III —Soft[a]
PHYSICAL PROPERTIES						
Specific Gravity	D792	1.23–1.34	1.29–1.34	1.28–1.34	1.27–1.34	1.27–1.34
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.10–0.19	0.10–0.19	0.10–0.19	0.10–0.19	0.10–0.19
Coef of Ther Exp, 10^{-5} per °F	D696	4.4–9.0	4.4–9.0	4.4–9.0	4.4–9.0	4.4–9.0
Refractive Index	D542	1.46–1.50	1.46–1.50	1.46–1.50	1.46–1.50	1.46–1.50
Spec Ht, Btu/lb/°F		0.3–0.42	0.3–0.42	0.3–0.42	0.3–0.42	0.3–0.42
Transmittance (luminous), %	D791	80–90	75–90	75–90	80–90	80–95
Haze, %	D672	2–10	2–15	2–15	2–10	2–8
Water Absorption (24 hr), %	D570	1.7–5.7	1.5–3.5	1.7–3.6	1.7–5.3	2.3–6.5
Flammability, ipm[b]	D635	0.5–2.0	0.5–2.0	0.5–2.0	0.5–2.0	—
MECHANICAL PROPERTIES						
Ten Str, 1000 psi	D638	2.7–6.5	6–8.5	5.4–8.2	4.6–7.5	1.9–4.7
Elong (in 2 in.), %	D638	18–54	6–31	10–35	17–40	32–70
Hardnıess (Rockwell)	D785	R68–115	R112–123	R106–121	R95–119	R39–103
Impacı Str (Izod notched), ft-lb/in.	D256	1.1–4.0	0.4–1.9	0.6–2.3	0.7–2.7	1.7–5.2
Mod o Elast in Flex, 10^5 psi		1.1–3.5	2.6–4.0	1.9–3.4	1.6–3.3	0.5–2.5
Compr Str, 1000 psi	D695	14.5–25	25–36	22–33	19–28	13–20
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257	10^{10}–10^{13}	10^{10}–10^{14}	10^{10}–10^{13}	10^{10}–10^{13}	10^{10}–10^{14}
Dielec Str (short time), v/mil	D149	250–600	250–600	250–600	250–600	250–600
Dielec Const						
60 Cycles	D150	3.5–7.5	3.5–7.5	3.5–7.5	3.5–7.5	3.5–7.5
10^6 Cycles	D150	3.2–7.0	3.2–7.0	3.2–7.0	3.2–7.0	3.2–7.0
Dissipation Factor						
60 Cycles	D150	0.03–0.38	0.03–0.38	0.03–0.38	0.03–0.08	0.03–0.08
10^6 Cycles	D150	0.03–0.33	0.03–0.33	0.03–0.33	0.03–0.33	0.03–0.33
FABRICATING PROPERTIES						
Bulk Factor		2.0–2.6	2.0–2.6	2.0–2.6	2.0–2.6	2.0–2.6
Compression Molding						
Pressure, psi		500–5000	500–5000	500–5000	500–5000	500–5000
Temperature, F		300–400	390–475	375–450	350–425	290–330
Injection Molding						
Pressure, 1000 psi		8–32	8–32	8–32	8–32	8–32
Temperature, F		355–450	420–490	410–480	390–460	335–395
Extruding Temp, F		335–450	420–450	405–455	390–420	335–365
HEAT RESISTANCE		As these are thermoplastic materials, they gradually become softer as the temperature rises. Maximum service temperature depends on such factors as formula, design of part, humidity and service conditions				
CHEMICAL RESISTANCE		Unattacked by water, salt water solutions, white gasoline, oleic acid, 5% acetic acid and dilute sulfuric acid. Decomposed by 30% sulfuric, 10% nitric and 10% hydrochloric acids; sodium hydroxide; and 10% ammonium hydroxide. Dissolved by acetone and ethyl acetate				
USES		Automotive and radio knobs, tool handles, business machine keys. Electrical items such as fluorescent lamp supports, coil spools and contact bases. Toys and novelties, sunglass goggles and frames, spectacle frames, buttons and tags, appliance housings, shoe heels				

[a] ASTM D706.
[b] Self-extinguishing compositions are available.

Cellulose Acetate Butyrate and Cellulose Propionate—Molded, Extruded

Type →	ASTM	Cellulose Acetate Butyrate: Type I[a] (Medium)	Cellulose Acetate Butyrate: Type II[a] (Hard)	Cellulose Acetate Butyrate: Type III[a] (Soft)	Cellulose Propionate[b]
PHYSICAL PROPERTIES					
Specific Gravity	D792	1.16-1.24	1.19-1.25	1.15-1.22	1.18-1.24
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.10-0.19	0.10-0.19	0.10-0.19	0.10-0.19
Coef of Ther Exp (max), per °F	D696	6-9 $\times 10^{-5}$	6-9 $\times 10^{-5}$	6-9 $\times 10^{-5}$	7-9 $\times 10^{-5}$
Refractive Index	D542	1.46-1.49	1.46-1.49	1.46-1.49	1.46-1.48
Spec Ht, Btu/lb/°F		0.3-0.4	0.3-0.4	0.3-0.4	0.3-0.4
Transmittance (luminous), %	D791	80-92	75-92	85-95	80-92
Haze, %	D672	2-5	2-5	2-5	2-5
Water Absorption (24 hr), %	D570	1.3-2.1	1.5-2.2	1.1-2.1	1.2-2.0
Flammability, ipm[c]	D635	0.5-1.5	0.5-1.5	0.5-1.5	1.0-1.5
MECHANICAL PROPERTIES					
Ten Str, 1000 psi	D638	2.9-5.7	5.0-6.8	1.9-3.8	1.5-7.5
Elong, %		47-66	38-54	60-74	50-60
Hardness (Rockwell)		R79-112	R108-114	R59-95	R20-120
Impact Str (Izod notched), ft-lb/in.	D256	1.0-4.3	0.6-2.4	2.5-5.4	0.8-11.0
Mod of Elast in Flex, psi		0.93-1.7 $\times 10^{5}$	1.5-2.0 $\times 10^{5}$	0.74-1.3 $\times 10^{5}$	1.6-3.3 $\times 10^{5}$
Flex Str, 1000 psi		No break	No break	No break	No break
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10^{10}-10^{12}	10^{10}-10^{12}	10^{10}-10^{12}	10^{12}-10^{15}
Dielec Str (short time), v/mil	D149	250-400	250-400	250-400	300-450
Dielec Const					
60 Cycles	D150	3.5-6.4	3.5-6.4	3.5-6.4	—
10^6 Cycles	D150	3.2-6.2	3.2-6.2	3.2-6.2	3.4-3.6
Dissip Factor					
60 Cycles	D150	0.01-0.04	0.01-0.04	0.01-0.04	—
10^6 Cycles	D150	0.01-0.04	0.01-0.04	0.01-0.04	0.02-0.03
FABRICATING PROPERTIES					
Bulk Factor		2.0-2.4	2.0-2.4	2.0-2.4	1.6-2.0
Compression Molding					
Pressure, 1000 psi		18	18	0.5-5	—
Temperature, F		265-340	320-390	265-305	—
Injection Molding					
Pressure, 1000 psi		8-32	8-32	8-32	8-32
Temperature, F		355-440	390-480	335-395	335-480
Mold Shrinkage, in./in.		0.001-0.008	0.001-0.009	0.001-0.006	0.002-0.006
HEAT RESISTANCE					
Heat Dist Temp, F					
66 Psi	D648	156-197	188-233	139-164	130-200
264 Psi	D648	130-172	158-210	121-137	100-190
CHEMICAL RESISTANCE		Unaffected by 3% sulfuric, 5% acetic, 10% hydrochloric and oleic acids; discolored by 10% nitric acid. Unaffected by 1% sodium hydroxide and 2% sodium carbonate; slightly softened by 10% sodium hydroxide and discolored by 10% ammonium hydroxide. Unaffected by white gasoline, but swollen or dissolved by ethyl alcohol, acetone, ethyl acetate, ethylene dichloride, carbon tetrachloride and toluene. Unaffected by water, salt water and 3% hydrogen peroxide			
USES		Telephone handsets, steering wheels, automobile white-wall disks, film spools, irrigation tubing, radio housings. Electrical items such as fluorescent light supports, coil spools and contact bases.			Pen and pencil parts, telephone handsets. Other uses similar to those of butyrate

[a] ASTM D707.
[b] Values given are for compounds having different plasticizer contents.
[c] Self-extinguishing cellulose acetate butyrate compounds are available.

Cellulose Nitrate and Ethyl Cellulose—Molded, Extruded

Type ➡		Cellulose Nitrate Sheet	Ethyl Cellulose Moldings		
			General Purpose	High Impact A	High Impact B
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.35-1.40	1.10-1.16	1.10-1.16	1.10-1.16
Ther Cond, Btu/hr/sq ft/°F/ft	Cenco-Fitch	0.133	0.092-0.167	0.092-0.167	0.092-0.167
Coef of Ther Exp, 10^{-5} per °F	D696	4.4-6.6	5.5-11	5.5-11	5.5-11
Refractive Index	D542	1.49-1.51	1.47	1.47	1.47
Transmittance (luminous), %	D791	89-92[a]	—	—	—
Haze, %	D672	2.0-4.0[a]	—	—	—
Water Absorption (24 hr), %	D570	1.0-2.0	1.2-2.0	0.8-2.0	1.0-2.0
Flammability (>0.050 in.), ipm	D635	[b]	0.5-1.5	0.5-1.5	0.5-1.5
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638	1.9-2.2	0.5-3.5	1.0-3.0	1.0-3.0
Ten Str, 1000 psi	D638	7-8	3-7	4-6.5	3-5
Strain at Fracture, %	D638	40-50	—	—	—
Hardness (Rockwell)	D785	R95-115	R80-120	R80-90	R70-80
Impact Str (Izod notched), ft-lb/in.	D758	5-7	1.7-6.0	3.5-6.0	4.0-7.0
Mod of Elast in Flex, 10^5 psi	D790	2.3-2.5	—	—	—
Flex Str, 1000 psi	D790	9-11[c]	4-10	6	4
Compr Str, 1000 psi	D695	22-35	—	—	—
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	$10\text{-}15 \times 10^{10}$	$10^{12}\text{-}10^{14}$	$10^{12}\text{-}10^{14}$	$10^{12}\text{-}10^{14}$
Dielec Str (short time), v/mil	D149	300-600	350-500	350-500	350-500
Dielec Const					
60 Cycles	D150	7.0-7.5	—	—	—
10^6 Cycles	D150	6.4	2.8-3.5	2.8-3.3	3.0-3.6
Dissip Factor					
60 Cycles	D150	0.09-0.12	—	—	—
10^6 Cycles	D150	0.06-0.09	0.010-0.060	0.010-0.030	0.018-0.035
FABRICATING PROPERTIES					
Bulk Factor		—	1.8-2.4	1.8-2.4	1.8-2.4
Compression Molding					
Pressure, 1000 psi		—	0.5-5	0.5-5	0.5-5
Temperature, F		—	250-390	250-390	250-390
Injection Molding					
Pressure, 1000 psi		—	6-32	8-32	8-32
Temperature, F		—	350-500	350-500	350-500
Hot Forming Temperature, F		135-250	—	—	—
Extruding Temperature, F		180-200	300-450	350-450	350-450
HEAT RESISTANCE					
Max Rec Svc Temp, F		120-140	—	—	—
Heat Dist Temp, F					
66 Psi		200-220	—	—	—
264 Psi		140-160	120-160	130-145	125-140
CHEMICAL RESISTANCE		Resistant to 30% sulfuric acid, carbon tetrachloride, 10% sodium chloride, 10% nitric acid, 10% hydrochloric acid, 5% acetic acid, 2% sodium tetrachloride, distilled water, aliphatic and aromatic hydrocarbons, and < 1% sodium hydroxide. Soluble in ketones, esters, lower alcohols and glycol ethers. Attacked by concentrated sodium hydroxide, ethylene dichloride and 50% ethanol	Unaffected by 3 sulfuric, 5 acetic and 10% hydrochloric acids; 10% sodium hydroxide, 2% sodium carbonate and water. Slightly affected by 30 sulfuric and 10% nitric acids; and 10% ammonium hydroxide. Attacked by 95% ethyl alcohol, acetone, toluene and gasoline		
USES		Fountain pens, spectacle frames, drawing instruments, ping-pong and billiard balls	Radio housings, toothbrushes, pen and pencil barrels, tool handles		

[a] ⅛-in. sheet containing no color.
[b] Cellulose nitrate under 0.050 in. thick burns very rapidly (D568).
[c] No break; specimen failed by slipping through supports.

Diallyl Phthalate—Molded

Type →	ASTM	Orlon-Filled	Dacron-Filled	Asbestos-Filled	Glass Fiber-Filled
PHYSICAL PROPERTIES					
Specific Gravity	D792	1.31–1.34	1.40	1.65–1.70	1.55–1.59
Coef of Ther Exp, per °F	D696	1.5×10^{-5}	2.0×10^{-5}	3.5×10^{-5}	$2.2–2.6 \times 10^{-5}$
Water Abs (122 F, 48 hr), %		0.2–0.5	0.2–0.5	0.4–0.5	0.2–0.4
Flammability (ignition time), sec		68	84–90	70	70–400
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi[a]	D638	6×10^5	—	12×10^5	—
Ten Str, psi	D638	4500–6000	4600–6000	4000–5500	5500–7000
Hardness (Rockwell)	D785	M108	—	M107	M108
Impact Str (Izod notched), ft-lb/in.	D256	0.5–1.2	1.7–4.5	0.30–0.45	0.5–6.0
Flex Str, 1000 psi	D790	10–10.5	9–11.5	8–10	10–18
Compr Str, 1000 psi	D695	20–30	20–30	18–25	25
ELECTRICAL PROPERTIES					
Dielec Str, v/mil					
Short Time (dry)	D149	400	376–390	450	350–430
Short Time (wet[b])	D149	375	360–391	400	300–420
Step by Step (dry)	D149	350	350–374	400	300–420
Step by Step (wet[b])	D149	325	350–361	350	275–420
Dielec Breakdown, kv					
Short Time (dry)		65–75	70–80	55–80	63–70
Short Time (wet[b])		60–65	66–70	55	45–65
Step by Step (dry)		55–60	60–65	38–70	60–65
Step by Step (wet[b])		46–60	50–60	39–60	49–65
Dissip Factor[c]					
Dry	D150	0.023, 0.015	0.008, 0.015	0.05, 0.03	0.01, 0.015
Wet[d]	D150	0.026, 0.020	0.009, 0.017	0.042, 0.154	0.012, 0.020
Dielec Const[c]					
Dry	D150	3.9, 3.3	3.8, 3.4	5.2, 4.5	4.5, 4.2
Wet[d]	D150	4.1, 3.4	3.9, 3.6	4.8, 4.2	4.6, 4.4
Vol Res, megohm-cm[d]	D257	60,000	100–25,000	6000	40,000
Surface Res, megohms[d]	D257	25,000	500–25,000	6000	25,000
Arc Resistance, sec	D495	85–115	105–125	125–140	125
FABRICATING PROPERTIES					
Bulk Factor	D392	3.5–5.2	3.5–5.2	1.9–2.4	1.9–5.0
Compression Molding					
Pressure, psi		500–2000	500–2000	500–2000	500–2000
Temperature, F		270–290	270–290	270–320	270–320
Transfer Molding					
Pressure, psi		1000–5000	1000–5000	1000–5000	1000–5000
Temperature, F		270–290	270–290	270–310	270–310
Mold Shrinkage, in./in.		0.009	0.010	0.004–0.007	0.001–0.004
Post-Mold Shrinkage (480 hr, 257 F), in./in.		0.001	0.0006	0.0005	0.0005–0.0007
HEAT RESISTANCE					
Max Rec Svc Temp, F		300	300–370	350–450	400–450
Heat Dist Temp, F	D648	240–266	270–290	300–350	400–500
CHEMICAL RESISTANCE		Unaffected by weak acids and alkalis and organic solvents. Slightly affected by strong acids and alkalis			

[a] Conditioned 48 hr at 122 F.
[b] Tested after 48-hr immersion in water at 122 F.
[c] Values given for frequencies of 1 kc and 1 mc, in that order.
[d] Conditioned 30 days at 100% RH and 158 F.

Epoxies—Cast, Molded

Type ➔		Cast			Molded[b]
		General Purpose	Resilient	Heat Resistant	
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.12–2.4	1.0–1.25	1.15–3.2	1.5–2.0
Ther Cond, Btu/hr/sq ft/°F/ft	D325	0.1–0.8	0.1	0.1–0.8	0.1–0.5
Coef of Ther Exp, per °F	D696	1.7–5.0 x 10^{-6}	2.8–4.4 x 10^{-6}	2.8–3.3 x 10^{-6}	1.5–2.7 x 10^{-6}[c]
Water Absorption (24 hr), %	D570	0.1–0.5	0.4	0.01–0.2	0.06–0.08
Linear Mold Shrinkage, in./in.		0.001–0.01	—	0.01	0.001–0.015
Flammability, ipm	D635	0.3 to self-exting	—	0.3 to self-exting	0.3 to self-exting
MECHANICAL PROPERTIES					
Ten Str, 1000 psi	D651	2–12	0.1–4.0	5–14	5–16
Elongation, %	D651	2–6	150–10	2–5	—
Hardness (Rockwell)	D785	M75–110	[a]	M90–110	M110
Impact Str (Izod), ft lb/in. notch	D256	0.2–0.7	0.5–7.0	0.2–1.5	0.3–30.0
Mod of Elast in Flex, 10^6 psi	D790	0.4–1.5	Up to 0.2	0.4–1.5	0.8–3.0
Flex Str, 1000 psi	D790	8–20	Up to 15	8–20	9–30[d]
Compr Str, 1000 psi	D695	20–40	3–20	25–40	25–26
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10^{13}–10^{14}	10^{11}–10^{13}	10^{12}–10^{14}	0.1–9 x 10^{15}
Dielec Str (⅛ in.), v/mil					
Short Time	D149	350–550	350–550	350–550	350–550
Step-by-Step	D149	350–550	350–550	350–550	350–550
Surface Res, ohms	D257	10^{12}–10^{14}	10^{12}–10^{13}	10^{12}–10^{14}	64 x 10^{12}
Dielectric Constant					
60 Cycles	D150	3.5–5.0	3.5–4.5	4.0–4.5	4.4–5.4
1000 Cycles	D150	3.5–5.0	3.3	3.8–4.1	4.2–5.0
10^6 Cycles	D150	3.4–4.4	2.6–2.8	3.5–4.0	4.1–4.6
Dissipation Factor					
60 Cycles	D150	0.001–0.015	0.05	0.005–0.013	0.011–0.018
1000 Cycles	D150	0.002–0.017	0.04	0.012–0.015	0.019–0.025
10^6 Cycles	D150	0.015–0.035	0.04	0.012–0.032	0.013–0.020
Loss Factor					
60 Cycles	D150	0.02–0.07	—	0.022	0.048–0.097
1000 Cycles	D150	0.02–0.09	—	0.053	0.080–0.125
10^6 Cycles	D150	0.09–0.13	—	0.12	0.053–0.092
Arc Resistance, sec	D495	65–100	—	65–120	100–180
HEAT RESISTANCE					
Max Rec Svc Temp, F		175	122	400	400
Heat Dist Temp (264 psi), F	D648	Up to 250	—	Up to 500	210–500
USES		Potting and encapsulation of electrical and electronic components, precision castings, tools and dies, patching compounds			New materials; primary uses probably electrical moldings of all types, such as condensers, switch plates, connector plugs, resistor bobbins and wirewound resistors, molded coils, relay assemblies

[a] Shore A up to 100.
[b] Values cover range obtainable with mineral filler or mineral and glass fiber filler. Compounds designed for compression or transfer molding without release agents. Data, in some cases are preliminary.
[c] 77–140 F. [d] After post-cure.

Fluorocarbons—Molded, Extruded

Type →	ASTM	Polytrifluorochloro-ethylene	Polytetrafluoro-ethylene	Fluorinated Ethylene Propylene
PHYSICAL PROPERTIES				
Specific Gravity	D792	2.10–2.15	2.1–2.3	2.14–2.17
Ther Cond, Btu/hr/sq ft/°F/ft	[a]	0.145	0.14	0.11
Coef of Ther Exp, per °F	D696	3.88×10^{-5}	5.5×10^{-5}	$8.3–10.5 \times 10^{-5}$
Refractive Index	D542	1.43	1.35	1.34
Specific Heat, Btu/lb/°F		0.22	0.25	0.28
Transmittance (luminous), %	D791	80–92	—	—
Water Absorption (24 hr), %	D570	0.00	0.00	0.00
Flammability		Noninflammable	Noninflammable	Noninflammable
MECHANICAL PROPERTIES				
Mod of Elast in Compression, psi	D638	1.8×10^{5}	$0.70–0.90 \times 10^{5}$	$0.6–0.8 \times 10^{5}$
Mod of Elast in Tension, psi	D638	$1.9–3.0 \times 10^{5}$	$0.38–0.65 \times 10^{5}$	$0.5–0.7 \times 10^{5}$
Tensile Strength, 1000 psi	D638	4.6–5.7	2.5–3.5	2.5–3.5
Elongation (in 2 in.), %	D638	125–175	250–350	300–900
Hardness (Rockwell)	D785	R110–115	J75–95	D55
Abrasion Resistance, gm/cycle	[b]	0.0080	—	—
Impact Strength (Izod notched), ft-lb/in.	D256	3.50–3.62	2.5–4.0	No break
Mod of Elast in Flexure, psi	D747	$2.0–2.5 \times 10^{5}$	0.6×10^{5}	0.8×10^{5}
Flexural Strength (0.1% offset), 1000 psi	D790	3.5	1.6	—
Compressive Strength (0.1% offset), 1000 psi	D695	2.0	0.7–1.8	1.6
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257	10^{18}	10^{19}	10^{18}
Dielectric Strength (short time), v/mil	D149	530–600	400–500	500–600
Dielectric Constant				
60 Cycles	D150	2.6–2.7	2.0	2.1
10^{6} Cycles	D150	2.30–2.37	2.0	2.1
Dissipation Factor				
60 Cycles	D150	0.02	0.0002	0.0003
10^{6} Cycles	D150	0.007–0.010	0.0002	0.0006
Arc Resistance, sec		>360	>200	>165
FABRICATING PROPERTIES				
Injection Molding				
Pressure, 1000 psi		5–30	—	5–20
Temperature, F		420–620	—	625–760
Compression Molding				
Pressure, 1000 psi		0.1–15	—	1–2
Temperature, F		445–525	—	600–750
Bulk Factor		2.5	—	—
Mold Shrinkage, in./in.		0.005–0.010	—	0.03–0.06
HEAT RESISTANCE				
Max Rec Svc Temp, F		380	500	400
Heat Dist Temp, F				
66 Psi	D648	196–291	—	—
264 Psi	D648	151–178	—	—
CHEMICAL RESISTANCE		Impervious to corrosive chemicals; highly resistant to most organic solvents. Swelling may occur with some highly halogenated and aromatic compounds	Inert to most chemicals and solvents with the exception of alkali metals. Halogenated solvents at high temperatures and pressure have some effect	
USES		Chemical pipes, gaskets, pump parts, electrical cables, tank linings, connectors, coil forms, connector inserts, valve diaphragms, electrical insulation	Chemical pipes, valves and valve liners, gaskets and packings, pump bearings and impellers, electrical and electronic equipment, anti-adhesive coatings	Molded electronic and instrument components, valve linings, laminates, corrosion resistant and non-adhesive coatings

[a] Cenco-Fitch.
[b] Federal Spec. L-P-406A No. 1092.1.

Melamines—Molded

Filler and Type →	ASTM	Alpha Cellulose—General Purpose	Mineral—Electrical	Fabric—Low to Intermediate Shock Resistant	Fabric—Intermediate Resistance
PHYSICAL PROPERTIES					
Specific Gravity	D792	1.47–1.52	1.7–2.0	1.5	1.5
Ther Cond, Btu/hr/sq ft/°F/ft		0.17–0.24	0.32–0.41	0.257	0.25–0.26
Coef of Ther Exp, per °F	D696	$1.11–3.17 \times 10^{-5}$	$1.06–2.50 \times 10^{-5}$	1.55×10^{-5}	1.55×10^{-5}
Transmittance (luminous), %		14.5	Opaque	Low	—
Water Absorption (24 hr), %	D570	0.1–0.6	0.08–0.14	0.3–0.6	0.2–1.3
Flammability		Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	D638	$13–16 \times 10^5$	$16–19.5 \times 10^5$	16×10^5	16×10^5
Ten Str, 1000 psi	D638	7–10	5.5–7.0	8–9.5	5.7–9
Elong (in 2 in.), %	D638	—	0.30–0.45	0.6–0.8	0.6
Hardness (Rockwell)	D785	M118–124, E110	M110	M120	M115
Impact Str (Izod notched), ft-lb/in.	D256	0.24–0.35	0.28–0.40	0.5–0.9	1.0–1.5
Mod of Elast in Flex, psi	D790	15×10^5	16×10^5	18.5×10^5	19×10^5
Compr Str, 1000 psi	D695	40–45	25–30	30–35	25–32
Flex Str, 1000 psi	D790	10–16	8.7–11	12–15	13–17
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	$10^{12}–10^{14}$	$10^{11}–10^{13}$	$10^{9}–10^{12}$	—
Dielec Str (short time), v/mil	D149	310–330	350–430	250–350	130–370
Dielec Const					
60 Cycles	D150	8.4–9.4	6.4–10.2	7.6–8.6	10.5–15.5
10^6 Cycles	D150	5.6–5.8	6.1–6.7	6.5–6.9	6.1–6.7
Dissip Factor					
60 Cycles		0.05–0.08	0.07–0.17	0.07–0.11	0.10–0.32
10^6 Cycles		0.03–0.04	0.04–0.05	0.036	0.050–0.065
Arc Resistance, sec	D495	122–128	120–170	115–128	5–8
FABRICATING PROPERTIES					
Bulk Factor	D392	2.1–3.1	2.1–2.5	5–10	5–10
Compression Molding					
Pressure, 1000 psi		1.5–8	1–7	4–8	4–8
Temperature, F		280–370	275–34C	275–330	300–380
Transfer Molding					
Pressure, 1000 psi		4–12	4–20	—	—
Temperature, F		300–320	270–340	—	—
Mold Shrinkage, in./in.		0.006–0.015	0.003–0.007	0.003–0.004	0.004–0.005
HEAT RESISTANCE					
Max Rec Svc Temp, F		210	250–400	250	250
Heat Dist Temp (264 psi), F	D648	350–410	265	310	375
CHEMICAL RESISTANCE		Resistant to weak acids, weak alkalis, organic solvents, greases and oils. Attacked by strong acids and strong alkalis			
USES		General purpose electrical and mechanical applications such as kitchenware, tableware, lighting fixtures, reflectors	Elevated temperature and electrical applications such as ignition parts, circuit breakers, terminal blocks, electronic parts	Applications requiring improved impact strength, such as insulation, circuit breakers, food trays, medical equipment	Applications requiring medium impact strength, such as nozzles, insulation

Melamines—Molded

Filler and Type →	ASTM	Unfilled	Cellulose Electrical	Glass Fiber	Alpha Cellulose and Mineral
PHYSICAL PROPERTIES					
Specific Gravity	D792	1.48	1.43–1.50	1.9–2.0	1.49
Ther Cond, Btu/hr/sq ft/°F/ft		—	0.17–0.20	0.28	—
Coef of Ther Exp, per °F	D696	—	1.11–2.78 x 10^{-5}	0.82 x 10^{-5}	—
Transmittance (luminous), %		Good	Opaque	—	—
Water Absorption (24 hr), %	D570	0.3–0.5	0.27–0.80	0.10–0.60	0.5
Flammability		Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	D638	—	10–11 x 10^5	—	—
Ten Str, 1000 psi	D638	—	5–9	6–10	5
Elong (in 2 in.), %	D638	—	0.6	—	—
Hardness (Rockwell)	D785	—	M115–125	—	—
Impact Str (Izod notched), ft-lb/in.	D256	—	0.27–0.36	4.0–12.0	0.30
Mod of Elast in Flex, psi	D790	13 x 10^5	1.0–1.3 x 10^5	—	—
Compr Str, 1000 psi	D695	40–45	25–33.6	26–32	—
Flex Str, 1000 psi	D790	11–14	9–10	10–23	8
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	—	10^{12}–10^{13}	1–7 x 10^{11}	10^{12}
Dielec Str (short time), v/mil	D149	—	350–400	250–300	375
Dielec Const					
60 Cycles	D150	—	6.2–7.6	9.7–11.1	—
10^6 Cycles	D150	—	4.7–7.0	6.9–7.2	6.4
Dissip Factor					
60 Cycles		—	0.019–0.033	0.14–0.23	—
10^6 Cycles		—	0.032–0.06	0.02–0.03	0.031
Arc Resistance, sec	D495	100–145	95–135	180–186	125
FABRICATING PROPERTIES					
Bulk Factor	D392	2.0	2.2–2.6	5–7	2.4
Compression Molding					
Pressure, 1000 psi		2–5	1.5–3	2–8	2–5
Temperature, F		300–340	290–360	280–340	280–350
Transfer Molding					
Pressure, 1000 psi		—	6–20	8–20	2–10
Temperature, F		—	300–330	290–310	285–350
Mold Shrinkage, in./in.		0.011–0.012	0.006–0.008	0.001–0.004	0.006–0.007
HEAT RESISTANCE					
Max Rec Svc Temp, F		210	250–280	300–400	275–325
Heat Dist Temp (264 psi), F	D648	293–298	265	400	300
CHEMICAL RESISTANCE		Resistant to weak acids, weak alkalis, organic solvents, greases and oils. Attacked by strong acids and strong alkalis			
USES		Pearlescent buttons, moldings ornamental applications	General mechanical and electrical applications, particularly at elevated temperatures. Applications requiring improved holding power for metallic inserts such as electrical and electronic parts	Applications requiring high shock resistance, good electrical properties, and high resistance to burning. Switchgear, terminal strips, standoff insulators, coil forms	Primarily electrical applications requiring low after-shrinkage, good dimensional stability and excellent molding characteristics

Polyamides (Nylons)—Molded, Extruded

Type →		66 Nylon			610 Nylon	
		General Purpose Injection Molding		Extrusion and Injection Molding	Extrusion and Injection Molding	
		0.2% Water	2.5% Water		0.2% Water	1.5% Water
PHYSICAL PROPERTIES	**ASTM**					
Specific Gravity	D792	1.14	—	1.14	1.09	—
Ther Cond, Btu/hr/sq ft/°F/ft	*	0.14	—	0.142	0.12	—
Coef of Ther Exp, 10^{-5} per °F	D696	5.5	—	5.5	5.5	—
Spec Ht, Btu/lb/°F		0.3-0.5	—	0.4	0.3-0.5	—
Refractive Index	D542	1.53	—	—	1.53	—
Water Absorption (24 hr), %	D570	1.5	—	1.5	0.4	—
Flammability	D757	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638	4.1	1.75	4.0	2.8	1.6
Ten Str, 1000 psi	D638	11.8	11.2	11.2-12.6	8.5	7.1
Elong (in 2 in.), %	D638	60	300	100-200	85	320
Hardness (Rockwell)	D785	M79, R118	M59, R108	R118	R111	—
Impact Str (Izod notched), ft-lb/in.	D256	0.9	2.0	1.1-1.5	0.6	1.6
Mod of Elast in Flex, 10^5 psi	D790	4.1	1.75	—	2.8	1.6
Flex Yld Str, 1000 psi	D790	13.8	—	13.8	8	—
Compr Yld Str, 1000 psi	D695	13	—	—	7.2	—
Compr Yld Str (1% def), 1000 psi	D695	—	—	4.9	—	—
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257	—	—	4.5×10^{13}	—	—
Dielec Str (short time), v/mil	D149	385	—	385	470	—
Dielec Const						
60 Cycles	D150	4.0	7.6	4.1	3.9	—
10^6 Cycles	D150	3.6	3.6	3.4	—	—
Dissip Factor						
60 Cycles	D150	0.01	0.09	0.014	—	—
10^6 Cycles	D150	0.02	0.08	0.04	0.02	—
Arc Resistance, sec	D495	—	—	—	—	—
FABRICATING PROPERTIES						
Bulk Factor	D392	2.1	—	2.14	2.2	—
Injection Molding						
Pressure, 1000 psi		10-20	—	—	10-20	—
Temperature, F		520-650	—	—	450-600	—
Joining		Can be cemented with aqueous phenol or various proprietary adhesives. Spin welding, extrusion lamination and other techniques can be used in special cases				
HEAT RESISTANCE						
Max Rec Svc Temp, F		275-300	—	—	225	—
Heat Dist Temp, F						
66 Psi	D648	—	—	360	—	—
264 Psi	D648	—	—	150	—	—
CHEMICAL RESISTANCE		Inert to most organic chemicals such as esters, ketones, alcohols and hydrocarbons. Resist alkalis and salt solutions, but attacked by phenols, formic acid, strong mineral acids and strong oxidizing agents				
USES		Gears, bearings, automatic washing machine valves, rollers and slides, combs and brush backs, aerosol bottles, coil forms, and mechanical parts where lubrication is undesirable or difficult		Tubing, rods, pipe, sheeting, laminations	Jacketing for wire and cable; special molded parts	

*Cenco-Fitch.

Polyamides (Nylons)—Molded, Extruded

Type →		6 Nylon				
		General Purpose Injection Molding	Extrusion and Injection Molding	11 Nylon	Soluble Resin (solution, injection, extrusion)	Glass Fiber-Filled[d]
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792	1.13-1.14	1.14	1.1	1.12-1.13	1.30–1.51
Ther Cond, Btu/hr/sq ft/°F/ft	[a]	0.10-0.14	0.11-0.12	—	0.16	0.12
Coef of Ther Exp, 10^{-5} per °F	D696	4.6-5.4	4.6-7.1	5.5	8.2	1.25–1.7
Spec Ht, Btu/lb/°F		0.4	—	0.58	0.4	0.3–0.35
Water Absorption (24 hr), %	D570	1.6-2.0	2.1-3.3	0.4	2.0-5.5	0.2-1.4
Flammability	D757	Self-exting	Self-exting	Self-exting	Self-exting	Self-exting
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638	2.5-3.4	1.5-3.6	1.8-1.9	0.38	1.2–8.6
Ten Str, 1000 psi	D638	10.2-12	10.2-11.3	8.5	3.8-7.4	19-31
Elong (in 2 in.), %	D638	300	300	100-120	300-600	1.5–2.3
Hardness (Rockwell)	D785	R105-118	R103-111	A50-55	R45-83	E64–79
Impact Str (Izod notched), ft-lb/in.	D256	1.2-3.0	1.5-3.5	3.3-3.6	>16	2.5–5.0
Flex Yld Str, 1000 psi	D790	15.5	—	—	1-2	21–40
Compr Yld Str (1% def), 1000 psi	D695	7.1-9.7	6.7-8.8	—	0.8	15–25
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257	10^{13}–10^{15}	10^{13}–10^{15}	2×10^{13}	5×10^{13}	$1.5\text{-}5.5 \times 10^{15}$
Dielec Str (short time), v/mil	D149	420–485	440-500	425	420	400-500
Dielec Const						
60 Cycles	D150	4.5-11.5	5.1-14.0	3.3[c]	10.7	4.0-4.6
10^6 Cycles	D150	3.6-4.3	3.5-4.5	—	4.5	3.4-3.9
Dissip Factor						
60 Cycles	D150	0.03-0.07	0.06-0.10	0.03	0.19	0.018–0.026
10^6 Cycles	D150	0.03-0.13	0.03-0.11	0.02	0.14	0.17–0.22
Arc Resistance, sec	D495	—	—	—	—	90-150
FABRICATING PROPERTIES						
Bulk Factor	D392	1.60-1.68	1.72-1.82	2.2	2.5	2.0
Compression Molding						
Pressure, 1000 psi		—	—	—	1-2	—
Temperature, F		—	—	—	325-380	—
Injection Molding						
Pressure, 1000 psi		10-25	—	—	10-25	10-25
Temperature, F		440-550	—	—	300-500	500-650
Extruding Temp, F		450-550	430-550	—	500-550	—
Joining		Nylon adhesive or aqueous phenol		—	[b]	Same as nylon
HEAT RESISTANCE						
Max Rec Svc Temp, F		225-250	200-250	212-250	140	300-400
Heat Dist Temp, F						
66 Psi	D648	340	—	—	100	430-540
264 Psi	D648	145	—	—	—	425-530
CHEMICAL RESISTANCE		Resists esters, ketones, alkalis, weak acids, alcohols and common solvents. Not resistant to conc mineral acids	Resists petroleum oils and greases, alkalis, esters, ketones, alcohols and common solvents. Not resistant to mineral acids	Similar to other nylons	Resists ketones, alkalis and esters. Not resistant to alcohols, phenols, formic acid, and mineral acids	Attacked by strong acids. Fairly resistant to strong alkalis. Resists common solvents
USES		Bearings, gears, bushings, coil forms, brush backs, rod, tubing, tape	Abrasion resistant shielding on insulated wire and mechanical cable. Pipe, tubing	Electrical insulation and other nylon uses where low moisture absorption is needed	Jacketing for wire and cable, seals, packings, sheeting, adhesives, abrasion-resistant finishes	Gears, business machine parts, bearing cages, mechanical components

[a] Cenco-Fitch.
[b] Can be bonded with 70-30 methanol-water as cement, or 10% solution of resin in methanol-water as solvent.
[c] At 1000 cps.
[d] Covers range obtainable in 10 grades.

Phenolics—Molded

Type and Filler →	ASTM	General—Woodflour and Flock	Shock—Paper, Flock or Pulp	High Shock—Chopped Fabric or Cord	Very High Shock—Glass Fiber
PHYSICAL PROPERTIES					
Specific Gravity	D792	1.32–1.55	1.34–1.46	1.36–1.43	1.75–1.90
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.097–0.3[a]	0.1–0.16	0.097–0.170	0.20[a]
Coef of Ther Exp, 10^{-5} per °F	D696	1.66–2.50	1.6–2.3	1.60–2.22	0.88
Spec Ht, Btu/lb/°F	....	0.35–0.40	—	0.30–0.35	0.28–0.32
Water Absorption (24 hr), %	D570	0.3–0.8	0.4–1.5	0.4–1.75	0.1–1.0
Flammability	D635	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638	8–13	8–12	9–14	30–33
Ten Str, 1000 psi	D638, D651	5.0–8.5	5.0–8.5	5–9	5–10
Elong (in 2 in.), %	D638	0.4–0.8	—	0.37–0.57	0.2
Hardness (Rockwell)	D785	M108–120	—	M93–120	M95–100
Impact Str (Izod notched), ft-lb/in.	D256	0.24–0.50	—	0.6–8.0	10–33
Mod of Elast in Flex, 10^5 psi	D790	8–12	—	9–13	—
Flex Str, 1000 psi	D790	8.5–12	8.0–11.5	8–15	10–45
Compr Str, 1000 psi	D695	22–36	24–35	15–30	17–30
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10^9–10^{13}	1–50 x 10^{11}	>10^{10}	7–10 x 10^{12}
Dielec Str (short time), v/mil	D149	200–425	250–350	200–350	200–370
Dielec Const					
60 Cycles	D150	5.0–9.0	5.6–11.0	6.5–15.0	7.1–7.2
10^6 Cycles	D150	4.0–7.0	4.5– 7.0	4.5– 7.0	4.6–6.6
Dissip Factor					
60 Cycles	D150	0.05–0.30	0.08–0.35	0.08–0.45	0.02–0.03
10^6 Cycles	D150	0.03–0.07	0.03–0.07	0.03–0.09	0.02
Arc Resistance, sec	D495	5–60	5–60	5–60	60
FABRICATING PROPERTIES					
Bulk Factor	....	2.1–4.4	2.3–5.7	3.0–18.0	6.1–6.3
Compression Molding					
Pressure, 1000 psi	....	1.5–5.0	2–5	2–6.5	1–5
Temperature, F	....	290–380	290–380	280–380	500–5000
Transfer Molding					
Pressure, 1000 psi	....	2–10	2–10	2–12	—
Temperature, F	....	275–340	275–340	275–340	—
Mold Shrinkage, in./in.	....	0.005–0.008	0.004–0.009	0.002–0.009	0.0
HEAT RESISTANCE					
Max Rec Svc Temp, F	....	300–350	300	250–275	350–450
Heat Dist Temp, F	D648	260–340	290–340	250–340	600
CHEMICAL RESISTANCE		Severely attacked by strong acids and strong alkalis. Effects of dilute acids, alkalis and organic solvents vary with the reagent. Chemical resistance varies with the particular formulation and not all materials of a type are equally resistant			
USES		Mechanical applications include pulleys, wheels, motor housings, handles. Electrical uses include coil forms, ignition parts, condenser housings, fuse blocks, instrument panels. Thermal applications include handles, appliance connector plugs. Chemical uses include photographic development tanks, rayon spinning buckets and parts, milking machine cups. Decorative uses include radio and television cabinets, handles, knobs, buttons			

[a] Cenco-Fitch.

Phenolics—Molded

Type and Filler →	ASTM	High Frequency—Mineral	Shock & Heat—Mineral, Flour and Yarn	Heat—Mineral	Chemical (no filler)
PHYSICAL PROPERTIES					
Specific Gravity	D792	1.75–1.92	1.68–2.00	1.54–1.75	1.24–1.90
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.24–0.34	0.19–0.39	0.19–0.39	—
Coef of Ther Exp, 10^{-5} per °F	D696	1.05–1.44	0.83–1.17	1.17	2.4
Spec Ht, Btu/lb/°F		0.28–0.32	0.28–0.32	0.28–0.32	—
Water Absorption (24 hr), %	D570	0.01–0.07	0.1–0.5	0.2–0.5	0.15–0.60
Flammability	D635	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638	30–50	15–25	10–20	7–15
Ten Str, 1000 psi	D638, D651	5–7	4–9	4–6.5	4.5–7.5
Elong (in 2 in.), %	D638	0.10–0.53	—	—	—
Hardness (Rockwell)	D785	M100–110	M100–110	M98–115	M105–120
Impact Str (Izod notched), ft-lb/in.	D256	0.30–0.38	0.27–3.50	0.24–0.40	0.2–0.6
Mod of Elast in Flex, 10^5 psi	D790	30–40	10–25	10–20	7–15
Flex Str, 1000 psi	D790	8–12	7–15	3–10.5	7–12
Compr Str, 1000 psi	D695	15–25	15–25	15–35	18–32
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10^{13}	10^{10}–10^{12}	10^{11}–10^{12}	10^{11}–10^{12}
Dielec Str (short time), v/mil	D149	300–375	100–250	150–350	225–275
Dielec Const					
60 Cycles	D150	4.7–5.5	30–150	5.8–40.0	9–19
10^6 Cycles	D150	4.4–5.1	5–7	4.8– 8.0	5.5–7.0
Dissip Factor					
60 Cycles	D150	0.01–0.07	0.25–0.50	0.10–0.35	0.15–0.25
10^6 Cycles	D150	0.005–0.02	0.10–0.50	0.04–0.15	0.04–0.09
Arc Resistance, sec	D495	16	6–180	5–180	—
FABRICATING PROPERTIES					
Bulk Factor		2.1–2.7	3–14	2.0–2.8	1.9–3.0
Compression Molding					
Pressure, 1000 psi		2.0–5.5	2–6	2–6	2–6
Temperature, F		300–350	290–380	290–380	300–360
Transfer Molding					
Pressure, 1000 psi		2–10	2–12	2–9	2–10
Temperature, F		275–325	275–325	275–325	275–340
Mold Shrinkage, in./in.		0.003	0.0005–0.005	0.002–0.006	0.002–0.01
HEAT RESISTANCE					
Max Rec Svc Temp, F		250–300	350–400	375–425	300–425
Heat Dist Temp, F	D648	230–325	290–375	350–400	300–350

CHEMICAL RESISTANCE

Severely attacked by strong acids and strong alkalis. Effects of dilute acids, alkalis and organic solvents vary with the reagent. Chemical resistance varies with the particular formulation and not all materials of a type are equally resistant

USES

Mechanical applications include pulleys, wheels, motor housings, handles. Electrical uses include coil forms, ignition parts, condenser housings, fuse blocks, instrument panels. Thermal applications include handles, appliance connector plugs. Chemical uses include photographic development tanks, rayon spinning buckets and parts, milking machine cups. Decorative uses include radio and television cabinets, handles, knobs, buttons

continued on next page

Phenolics—Molded

Type and Filler ➡	ASTM	Arc Resistant—Mineral	Rubber Phenolic—Woodflour or Flock	Rubber Phenolic—Chopped Fabric	Rubber Phenolic—Asbestos
PHYSICAL PROPERTIES					
Specific Gravity	D792	1.8–3.0	1.24–1.35	1.30–1.35	1.60–1.65
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.24–0.34	0.12	0.05	0.04
Coef of Ther Exp, 10^{-5} per °F	D696	—	0.83–2.20	1.7	2.2
Spec Ht, Btu/lb/°F	....	0.28–0.32	0.33	—	—
Water Absorption (24 hr), %	D570	0.2	0.5–2.0	0.5–2.0	0.10–0.50
Flammability	D635	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638	—	4–6	3.5–6	5–9
Ten Str, 1000 psi	D638, D651	6	4.5–9	3.5	4
Elong (in 2 in.), %	D638	—	0.75–2.25	—	—
Hardness (Rockwell)	D785	—	M40–90	M57	M50
Impact Str (Izod notched), ft-lb/in.	D256	0.32	0.34–1.0	2.0–2.3	0.3–0.4
Mod of Elast in Flex, 10^5 psi	D790	—	4–6	3.5	5.0
Flex Str, 1000 psi	D790	10	7–12	7	7
Compr Str, 1000 psi	D695	20	12–20	10–15	10–20
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	6×10^{12}	10^{8}–10^{11}	10^{11}	10^{11}
Dielec Str (short time), v/mil	D149	380	250–375	250	350
Dielec Const					
60 Cycles	D150	7.4	9–16	15	15
10^6 Cycles	D150	—	5	5	5
Dissip Factor					
60 Cycles	D150	—	0.15–0.60	0.5	0.15
10^6 Cycles	D150	0.10	0.1–0.2	0.09	0.13
Arc Resistance, sec	D495	180	7–20	10–20	5–20
FABRICATING PROPERTIES					
Bulk Factor	....	2.4	2.5–4.0	4.6–8.0	2.5
Compression Molding					
Pressure, 1000 psi	....	2–5	2–6	2–6	2–6
Temperature, F	....	285–350	300–360	300–350	300–350
Transfer Molding					
Pressure, 1000 psi	....	2–10	2–12	2–12	2–12
Temperature, F	....	285–350	300–350	300–350	300–350
Mold Shrinkage, in./in.	....	0.004	0.005–0.010	0.003–0.006	0.005–0.008
HEAT RESISTANCE					
Max Rec Svc Temp, F	....	400	212–300	212–225	225–260
Heat Dist Temp, F	D648	335	220–270	220–280	250–300
CHEMICAL RESISTANCE		Severely attacked by strong acids and strong alkalis. Effects of dilute acids, alkalis and organic solvents vary with the reagent. Chemical resistance varies with the particular formulation and not all materials of a type are equally resistant			
USES		Mechanical applications include pulleys, wheels, motor housings, handles. Electrical uses include coil forms, ignition parts, condenser housings, fuse blocks, instrument panels. Thermal applications include handles, appliance connector plugs. Chemical uses include photographic development tanks, rayon spinning buckets and parts, milking machine cups. Decorative uses include radio and television cabinets, handles, knobs, buttons			

Phenolics—Cast

Type →		Type I—Mechanical and Chemical	Type II—General Purpose Decorative	Type III—General Purpose Transparent
PHYSICAL PROPERTIES	ASTM			
Specific Gravity	D792	1.31	1.32	1.33
Coef of Ther Exp, per °F	D696	$3.3–4.4 \times 10^{-5}$	$3.3–5.5 \times 10^{-5}$	$4.7–6.6 \times 10^{-5}$
Water Absorption (24 hr), %	D570	0.35–0.40	0.32–0.35	0.3–2.0
Flammability (>0.050 in.)	D635	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	D638	$4–5 \times 10^5$	$3–4.5 \times 10^5$	$1–3 \times 10^5$
Tensile Strength, 1000 psi	D638	6–9	5–7.2	2.5–4.5
Hardness (Rockwell)	D785	M93–120	M90–105	R98–120
Impact Strength (Izod notched), ft-lb/in	D256	0.30–0.45	0.30–0.45	0.23–0.35
Mod of Elast in Flexure, psi	D790	$3–5 \times 10^5$	$3–5 \times 10^5$	$1–3 \times 10^6$
Flexural Strength, 1000 psi	D790	11–17	10–15	4–7
Compressive Yield Strength (1% offset), 1000 psi	D695	14–18	12.8–15.8	4.5–6.5
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257	$1–7 \times 10^{12}$	$1–3 \times 10^{12}$	3×10^{11}
Dielectric Strength (short time), v/mil	D149	350–400	300–450	75–250
Dielectric Constant				
60 Cycles	D150	6.5–7.5	15–20	20–30
10^6 Cycles	D150	4.0–5.5	5.0–11.0	7–8
Loss Factor				
60 Cycles	D150	0.05–0.9	0.4–4.0	5.0–17.0
10^6 Cycles	D150	0.15–0.35	0.05–1.10	0.6–0.8
FABRICATING PROPERTIES	—	Castings produced by pouring resins into molds (generally made of lead). Resins converted to solid by heating several days at atmospheric pressure and temperatures below 212 F. After oven baking, casting is removed from mold and is ready for machining and polishing	Castings produced by pouring resins into molds (generally made of lead). Resins converted to solid by heating several days at atmospheric pressure and temperatures below 212 F. After oven baking, casting is removed from mold and is ready for machining and polishing	Castings produced by pouring resins into molds (generally made of lead). Resins converted to solid by heating several days at atmospheric pressure and temperatures below 212 F. After oven baking, casting is removed from mold and is ready for machining and polishing
HEAT RESISTANCE				
Heat Dist Temp, F				
66 Psi	D648	—	180–210	150–160
264 Psi	D648	170–195	160–185	130–140
CHEMICAL RESISTANCE		Unless specially formulated, do not resist strong alkalis or strong acids. Dilute alkalis: slight to marked attack depending on alkali. Dilute acids: no effect or slight decomposition depending on acid. Continuous immersion in acetone, Cellosolve, methyl alcohol or ethyl alcohol results in noticeable attack, depending on time, temperature and hardness of cast resin	Unless specially formulated, do not resist strong alkalis or strong acids. Dilute alkalis: slight to marked attack depending on alkali. Dilute acids: no effect or slight decomposition depending on acid. Continuous immersion in acetone, Cellosolve, methyl alcohol or ethyl alcohol results in noticeable attack, depending on time, temperature and hardness of cast resin	Unless specially formulated, do not resist strong alkalis or strong acids. Dilute alkalis: slight to marked attack depending on alkali. Dilute acids: no effect or slight decomposition depending on acid. Continuous immersion in acetone, Cellosolve, methyl alcohol or ethyl alcohol results in noticeable attack, depending on time, temperature and hardness of cast resin
USES		Drill and saw jigs, stretch press molds and dies for fabricating aircraft parts, furniture hardware, instrument casings, sporting goods, costume and ornamental jewelry	Drill and saw jigs, stretch press molds and dies for fabricating aircraft parts, furniture hardware, instrument casings, sporting goods, costume and ornamental jewelry	Drill and saw jigs, stretch press molds and dies for fabricating aircraft parts, furniture hardware, instrument casings, sporting goods, costume and ornamental jewelry

Polyesters—Cast

Type ➔	ASTM	Allyl Type	Rigid Styrene Type	Nonrigid Styrene Type
PHYSICAL PROPERTIES				
Specific Gravity	D792	1.30–1.45	1.12–1.46	1.06–1.25
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.116–0.121	0.10–0.12	—
Coef of Ther Exp, per °F	D696	2.8–5.6 x 10^{-5}	3.9–5.6 x 10^{-5}	—
Refractive Index	D542	1.50–1.58	1.53–1.58	1.50–1.57
Specific Heat, Btu/lb/°F		0.26–0.55	0.30–0.55	—
Water Absorption (24 hr), %	D570	0.03–1.0	0.15–0.60	0.40–2.5
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	D638	2–3 x 10^5	1.5–6.5 x 10^5	—
Tensile Strength, 1000 psi	D638	4.5–7	4–10	0.9–1.9
Elongation (in 2 in.), %	D638	—	<5	40–310
Hardness (Rockwell)	D785	M92–118	M65–115	—
Impact Strength (Izod notched), ft-lb/in.	D256	0.18–0.32	0.18–0.40	>7.0
Mod of Elast in Flexure, psi		3–8 x 10^5	3–9 x 10^5	0.001–0.1 x 10^5
Flexural Strength, 1000 psi	D790	6–14	7–19	—
Compressive Strength, 1000 psi	D695	20–26	12–37	—
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257	>10^{13}	>10^{13}	>10^{12}
Dielectric Strength (short time), v/mil	D149	330–500	340–570	220–400
Dielectric Constant				
60 Cycles	D150	3.2–5.2	2.8–4.4	4.2–7.0
10^6 Cycles	D150	3.3–4.8	2.8–4.0	3.7–6.1
Dissipation Factor				
60 Cycles	D150	0.006–0.02	0.003–0.04	0.02–0.18
10^6 Cycles	D150	0.024–0.045	0.006–0.04	0.02–0.06
Arc Resistance, sec	D495	120–150	115–135	125–145
HEAT RESISTANCE				
Max Rec Svc Temp, F	D648	300	250–300	200–250
Heat Dist Temp, F		120–320	120–420	250
CHEMICAL RESISTANCE		Attacked by oxidizing acids. Slightly attacked by strong alkalis. Resistant to organic solvents	Slightly to heavily attacked by strong acids. Attacked by strong alkalis, ketones and chlorinated solvents	
USES		Castings used for aircraft glazing, electrical components, decorative applications. Resins used for premix and prepreg molding materials, matched metal molding and hand lay-up molding		

Silicones—Molded

Type and Filler →		General—Mineral	Improved Impact—Glass Fiber	High Impact—Glass Fiber
PHYSICAL PROPERTIES	ASTM			
Specific Gravity	D792	1.8-2.0	1.8-2.0	1.65-2.00
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.089-0.097	0.039-0.097	0.089-0.097
Coef of Ther Exp, per °F	D696	2.78-3.23 x 10^{-5}	3.17-3.23 x 10^{-5}	0.45 x 10^{-5}
Water Absorption (24 hr), %	D570	0.1-0.15	0.1-0.15	0.1-0.15
Flammability, ipm	D635	0-78	0-60	25-100
MECHANICAL PROPERTIES				
Tensile Strength, 1000 psi	D651	4-4.3	4-4.3	4.4-5
Hardness (Rockwell)	D785	M89	M89	M85
Impact Strength (Izod notched), ft-lb/in.	D256	0.25-0.30	0.33-0.38	15.0-20.0
Mod of Elast in Flexure, psi	D790	10-13 x 10^5	9-11 x 10^5	15-19 x 10^5
Flexural Strength, 1000 psi	D790	6.8-7.5	10-14	10-14
Compressive Strength, 1000 psi	D695	16-20	12-16	10-15
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257	>3.4 x 10^{13}	>3.4 x 10^{13}	>5 x 10^{13}
Dielectric Strength (short time), v/mil	D149	350-400	300-400	250-400
Dielectric Constant				
60 Cycles	D150	4.1-4.5	4-5	4-5
10^6 Cycles	D150	3.8-4.3	4-5	3.6-5.1
Dissipation Factor				
60 Cycles	D150	0.010-0.014	0.008-0.011	0.006-0.030
10^6 Cycles	D150	0.006-0.010	0.007-0.011	0.005-0.020
Arc Resistance, sec	D495	250-420	100-350	100-350
Loss Factor				
60 Cycles	D150	0.041-0.063	0.041-0.058	0.029-0.035
10^6 Cycles	D150	0.023-0.043	0.034-0.056	0.025-0.077
FABRICATING PROPERTIES				
Bulk Factor		2.1-2.6	2.3-2.8	6-9
Compression Molding				
Pressure, 1000 psi		2-4	2-4	1-5
Temperature, F		300-350	300-350	300-350
Transfer Molding				
Pressure, 1000 psi		3.5-15	3.5-15	4.5-15
Temperature, F		300-350	300-350	300-350
Mold Shrinkage, in./in.		0.006-0.010	0.005-0.008	0.003-0.005
HEAT RESISTANCE				
Max Res Svc Temp, F		> 700	> 600	> 600
Heat Dist Temp, F	D648	> 900	> 900	> 900
CHEMICAL RESISTANCE		Resistant to aviation gasoline, lubricating oil, and sulfuric and hydrochloric acids. Slightly softened and pitted by sodium hydroxide, except some of the mineral-filled materials. Should be tested if resistance to ketones, toluene, ethylenes, etc., is required		
USES		Motor slot wedges, terminal boards, connector plugs, switches and insulators, aircraft brake assemblies, jet engine parts, aircraft ignition systems, guided missile parts, tube bases and caps		

Polystyrenes and Modified Polystyrenes—Molded, Extruded

Type →		Polystyrene		Modified Polystyrene		
		General Purpose	Glass Fiber-Filled	Heat & Chemical Resistant	Medium-High Impact[c]	Extra High Impact
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792	1.04–1.07	1.25–1.32	1.05–1.11	1.04–1.08	1.0–1.10
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.058–0.090	—	0.046–0.090	0.024–0.090	0.024–0.090
Coef of Ther Exp, 10^{-5} per °F	D696	3.3–4.8	2.2–2.4	3.6–3.8	3.3–4.7	2.2–5.6
Spec Ht, Btu/lb/°F		0.30–0.35	0.24–0.27	0.30–0.35	0.30–0.35	0.30–0.35
Refractive Index	D542	1.57–1.60	—	1.57–1.60	—	—
Transmittance (luminous), %		0–93	—	—	—	—
Water Absorption (24 hr), %	D570	0.03–0.05	0.05–0.07	0.1–0.3	0.03–0.08	0.05–0.20
Flammability, ipm	D635	1.0–1.5	—	0.4–1.0	0.5–2.0	0.5–2.0
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638	4–5	11–13	4–6	3.0–4.5	2.5–4.0
Ten Str, 1000 psi	D638	5–8	11–17	10–11	3.5–6.8	3.0–5.5
Elong (in 2 in.), %	D638	1.5–2.5	1.1–1.3	1–4	5–35	15–45
Hardness (Rockwell)	D785	M68–80	M90–100	M78–88	M15–80	M15–60
Impact Str (Izod), ft-lb/in. notch	D256	0.25–0.35	1.4–6.1	0.25–0.50	0.6–3.0	6–11
Mod of Elast in Flex, 10^5 psi		4–5	11–13	4–6	3.5–5.0	2.3–4.0
Flex Str, 1000 psi	D790	8–15	15–24	11–17	No failure	No failure
Compr Str, 1000 psi	D695	11.5–16	14–20	12–17	—	—
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257	10^{18}–10^{19}	3.5 x 10^{16}	10^{12}–10^{17}	10^{14}–10^{16}	10^{12}–10^{17}
Dielec Str (short time), v/mil	D149	>500	320–425	400–600	>450	300–650
Dielec Const						
60 Cycles	D150	2.5–2.6	2.95–3.50	2.5–3.4	2.45–2.70[d]	2.5–4.0
10^6 Cycles	D150	2.45–2.65	2.74–3.41	2.5–3.1	—	2.5–4.0
Dissip Factor						
60 Cycles	D150	0.0001–0.0004	0.005–0.014	0.001–0.008	0.0004–0.01[d]	0.003–0.0095[d]
10^6 Cycles	D150	0.0001–0.0005	0.00125–0.0028	0.001–0.008	—	—
FABRICATING PROPERTIES						
Bulk Factor		1.6–2.3	—	1.6–2.3	1.6–2.3	1.6–2.3
Compression Molding						
Pressure, 1000 psi		1–7.5	2–5	1–5	1–8	1–8
Temperature, F		275–400	275–350	325–450	325–475	300–450
Injection Molding						
Pressure, 1000 psi		10–24	15–20	10–24	10–24	10–30
Temperature, F		325–650	450–600	400–700	300–600	375–55[illegible]
Mold Shrinkage, in./in.		0.002–0.008	0.001–0.003	0.002–0.008	0.002–0.008	0.002–0.0[illegible]
HEAT RESISTANCE						
Max Rec Svc Temp, F		140–160[a]	190–200	175–190	125–165	120–160
Heat Dist Temp (264 psi), F	D648	165–190[b]	145–220	200–220	155–180	185–190
CHEMICAL RESISTANCE		Good resistance to alkalis, salts, lower alcohols, glycols, water. Fair resistance to mineral and vegetable oils. Soluble in aromatic and chlorinated hydrocarbons. Softened or attacked by higher alcohols, gasoline, strong oxidizing acids, chlorine		More resistant to attack by solvents, oils and other organic liquids than other polystyrenes	Similar to general purpose polystyrene	
USES		Electrical parts, incl storage battery cases, insulators, coil forms. Fluorescent light fixtures, rigid containers, instrument panels, nameplates, refrigerator parts, housewares, toys	Magnetic tape reels, housings and covers, yarn bobbins, structural support members, instrument panels, storage battery cases	Battery cases, coil forms, drafting instruments, sight glasses on pressure lubricating systems, thermostat housings	Coat hangers; toilet seats; refrigerator door panels, drawers and crispers; knobs; toys; vacuum formed sheet	Freezer lids, action toys, children's furniture

[a] 160–180 F for heat resistant grades.
[b] 180–205 F for heat resistant grades.
[c] Covers values obtainable in both Medium and High Impact grades.
[d] Average for wide frequency range.

ABS Resins and Methylstyrenes—Molded, Extruded

Type →		ABS Resins			Methylstyrene[b]	
		Medium-High Impact[a]	Extra-High Impact	Low Temp Impact	Polymethylstyrene	Methylstyrene-Acrylonitrile
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792	1.04–1.06	1.01–1.06	1.02	1.01–1.03	1.06
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.08–0.12	0.08–0.12	0.08–0.12	—	—
Coef of Ther Exp, 10^{-6} per °F	D696	4.7	4.7–5.6	4.7–5.6	—	—
Spec Ht, Btu/lb/°F		0.35–0.38	0.35–0.38	0.35–0.38	—	—
Refractive Index	D542	—	—	—	1.581	1.559
Transmittance (luminous), %		—	—	—	Transparent	Transparent
Water Absorption (24 hr), %	D570	0.2	0.3	0.2	0.05	0.31
Flammability, ipm	D635	1.3	1.3	1.3	Slow	Slow
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638	2.6–2.9	2.1–2.6	1.0	—	—
Ten Str, 1000 psi	D638	4.5–8.5	5–8	3–5	6.6–8.9	9.3
Elong (in 2 in.), %	D638	5–100	20–50	30–200	2.2–5.0	2.5
Hardness (Rockwell)	D785	R85–118	R85–100	R30–65	M76–83	M83
Impact Str (Izod), ft-lb/in. notch	D256	3.0–6.0	5–9	6–10	0.33	0.40
Impact Str (—40 F), ft-lb/in.		1.0	1.5	2.5	—	—
Mod of Elast in Flex, 10^5 psi		37–45	—	—	4.0	4.6
Flex Str, 1000 psi	D790	7.5–11.0	6.8–8.0	3–4	10-13	16
Compr Str, 1000 psi	D695	—	—	—	—	—
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm.	D257	$>8 \times 10^{13}$	1.8×10^{13}	$8.2–0.5 \times 10^{13}$	$2.6–5000 \times 10^{14}$	2.65×10^{11}
Dielec Str (short time), v/mil	D149	350–416	312	340–416	890–1950	610
Dielec Const						
60 Cycles	D150	2.7–4.2	2.7–4.76	2.7–4.0	—	—
10^6 Cycles	D150	2.8–3.6	3.78	2.8–4.1	2.48	2.81
Dissip Factor						
60 Cycles	D150	0.009–0.015	0.021	0.01	—	—
10^6 Cycles	D150	0.017–0.026	0.026	0.02	0.0006	0.0078
FABRICATING PROPERTIES						
Bulk Factor		2.25–2.27	2.29	2.27	—	—
Compression Molding						
Pressure, 1000 psi		>1	>1	>1	1–8	1–8
Temperature, F		325–375	325–375	325–375	300–375	300–375
Injection Molding						
Pressure, 1000 psi		6–30	6–30	6–30	10–30	10–30
Temperature, F		350–600	375–600	350–600	400–550	400–550
Mold Shrinkage, in./in		0.001–0.010	0.001–0.010	0.001–0.010	0.0046	0.0035
HEAT RESISTANCE						
Max Rec Svc Temp, F		—	—	—	210	212
Heat Dist Temp (264 psi), F	D648	185–215	185	175–185	213–216	215
CHEMICAL RESISTANCE		Highly resistant to aqueous acids, alkalis, salts. Resistant to concentrated phosphoric and hydrochloric acids, alcohols, and animal, vegetable and mineral oils. Disintegrated by concentrated sulfuric and nitric acids. Soluble in esters, ketones, ethylene dichloride			Same as polystyrenes	Resists aliphatic hydrocarbons, gasoline, essential oils, vegetable and mineral oils
USES		Pipe, appliance housings and wheels, protective sportswear, housewares, lawn and garden equipment, office equipment, toys, safety equipment, transportation. Also available as formable sheet for such uses as cases, luggage, refrigerator linings			Radio cabinets, housewares and household utility parts, refrigerator parts, decorative lighting, packaging, electronic components	Same as polymethylstyrene. Also metering sight glasses, fan blades, combs, automotive interior parts, machine housings

[a] Range covers values obtainable in both Medium and High Impact grades.
[b] Recently withdrawn from commercial production.

Polyethylenes—Molded, Extruded

Type ➔		Type I—Lower Density (0.910–0.925)			Type II—Medium Density (0.926–0.940)	
		Melt Index 0.3-3.6	Melt Index 6-26	Melt Index 200	Melt Index 12.0	Melt Index 1.0-1.9
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792	0.910–0.925	0.918–0.925	0.910	0.930	0.930–0.940
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.19	0.19	0.19	0.19	0.19
Coef of Ther Exp, 10^{-5} per °F	D696	8.9–11.0	8.9–11.0	11.0	8.3–16.7	8.3–16.7
Refractive Index	D542	1.51	1.51	1.51	1.51	1.51
Spec Ht, Btu/lb/°F		0.53–0.55	0.53–0.55	0.53–0.55	0.53–0.55	0.53–0.55
Water Absorption (24 hr), %	D570	<0.01	<0.01	<0.01	<0.01	<0.01
Flammability, ipm	D635	1.0	1.0	1.0	1.0	1.0
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638	0.21–0.27	0.20–0.24	—	—	—
Ten Str, 1000 psi	D412	1.4–2.5	1.4–2.0	0.9–1.1	2.0	2.3–2.4
Elong (in 2 in.), %	D412	500–725	125–675	80–100	200	200–425
Hardness (Shore)	D785	C73, D50–52	C73, D47–53	D45	D55	D55–D56
Impact Str (Izod), ft-lb/in. notch	D256	—	—	—	—	—
Brittleness Temp, F		<−94	<−4	<14	<−148	<−148
Mod of Elast in Flex, 10^3 psi	D747	13–27	12–30	10	43	35–50
Shear Str, 1000 psi		1.6–1.85	1.4–1.7	1	—	—
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257	10^{17}–10^{19}	10^{17}–10^{19}	10^{17}–10^{19}	>10^{15}	>10^{15}
Dielec Str (short time), v/mil	D149	480	480	480	480	480
Dielec Const	D150	2.3	2.3	2.3	2.3	2.3
Dissip Factor	D150	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
FABRICATING PROPERTIES						
Bulk Factor		1.6–2.2	1.6–2.2	1.6–2.2	1.6–2.2	1.6–2.2
Injection Molding						
Pressure, 1000 psi		5–22	5–15	2–10	10–15	10–15
Temperature, F		275–650	275–650	250–350	300–500	300–500
Mold Shrinkage, in./in.		0.02–0.05	0.01–0.04	0.01–0.02	0.02–0.05	0.02–0.05
HEAT RESISTANCE						
Vicat Softening Point, F		176–201	176–201	—	215	220–235
CHEMICAL RESISTANCE		Excellent resistance to acids and alkalis at normal temperature, except oxidizing acids such as nitric, chlorosulfonic and fuming sulfuric. Below 122 F, insoluble in organic solvents; at higher temperatures, soluble to varying degrees in hydrocarbons and halogenated hydrocarbons, but insoluble in more polar liquids. Generally, a higher melt index material has greater solubility				
USES		Injection moldings: kitchen utilityware, toys, process tank liners, closures, packages, sealing rings, battery parts. Blow moldings: squeeze bottles for packaging, containers for drugs. Film: wrapping materials for food, clothes, other items. Wire and cable: high frequency insulation, jacketing. Pipe: chemicals handling, irrigation systems, natural gas transmission				

Polyethylenes—Molded, Extruded

Type →	ASTM	Type III—Higher Density (0.942–0.960)			
		Melt Index 0.2-0.6	**Melt Index 0.1-12.0**	**Melt Index 1.5-5.0**	**Melt Index 0.2-0.9**
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	0.942–0.947	0.950–0.955	0.96	0.96
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.19	0.19	0.19	0.19
Coef of Ther Exp, 10^{-6} per °F	D696	8.3–16.7	8.3–16.7	8.3–16.7	8.3–16.7
Refractive Index	D542	1.54	1.54	1.54	1.54
Spec Ht, Btu/lb/°F		0.46–0.55	0.46–0.55	0.46–0.55	0.46–0.55
Water Absorption (24 hr), %	D570	<0.01	<0.01	<0.01	<0.01
Flammability, ipm	D635	1.0	1.0	1.0	1.0
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638	—	—	—	—
Ten Str, 1000 psi	D412	—	2.9–4.0	4.4	4.4
Elongation, %	D412	—	25–400	12–20	25–30
Hardness (Shore)	D785	D65–66	D60–70	D68–70	D68–70
Impact Str (Izod), ft-lb/in. notch	D256	1.5–6	0.4–6.0	1.2–2.5	4.0–14
Brittleness Temp, F		<−76	<−76 to <−170	−100 to −180	−106 to −180
Mod of Elast in Flex, 10^4 psi	D747	85–120	90–125	150	130–150
Shear Str, 1000 psi		—	—	—	—
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	$>10^{16}$	$>10^{16}$	$>10^{16}$	$>10^{16}$
Dielec Str (short time), v/mil	D149	480	480	480	480
Dielec Const	D150	2.3	2.3	2.3	2.3
Dissip Factor	D150	<0.0005	<0.0005	<0.0005	<0.0005
FABRICATING PROPERTIES					
Bulk Factor		1.6–2.2	1.6–2.2	1.6–2.2	1.6–2.2
Injection Molding					
Pressure, 1000 psi		10–15	10–15	10–15	10–15
Temperature, F		330–530	330–530	330–530	330–530
Mold Shrinkage, in./in.		0.02–0.05	0.02–0.05	0.02–0.05	0.02–0.05
HEAT RESISTANCE					
Vicat Softening Point, F		250	250–260	260*	260*
CHEMICAL RESISTANCE		Same basic chemical resistance as Types I and II, but better resistance to some specific chemicals			
USES		Refrigerator parts, packaging, structural housing panels, pipe, defroster and heater ducts, sterilizable housewares and hospital equipment, hoops, battery parts, blow molded containers and parts, film wrapping materials, wire and cable insulation, and chemical resistant pipe			

* Adapted from method of Karrer, Davis and Dieterich, *Ind. & Engrg. Chem.*, Vol. 2, No. 30, '30.

Polyvinyl Chloride and Copolymers—Molded, Extruded

Type →		Polyvinyl Chloride, Polyvinyl Chloride-Acetate			Vinylidene Chloride[a]
		Nonrigid—General	Nonrigid—Electrical	Rigid—Normal Impact	
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.20–1.55	1.16–1.40	1.32–1.44	1.68–1.75
Ther Cond, Btu/hr/sq ft/°F/ft	D325	0.07–0.10	0.07–0.10	0.07–0.10	0.053
Coef of Ther Exp, 10^{-5} per °F	D696	—	—	2.8–3.3	8.78
Refractive Index	D542	—	—	—	1.60–1.63
Spec Ht, Btu/lb/°F	D570	—	—	—	0.32
Water Absorption (24 hr), %	D635	0.2–1.0	0.40–0.75	0.03–0.40	>0.1
Flammability		Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D412	0.004–0.03	0.01–0.03	3.5–4.0[b]	0.7–2.0
Ten Str, 1000 psi	D412	1–3.5	2–3.2	5.5–9	4–8, 15–40
Elong (in 2 in.), %	D638	200–450	220–360	5–25	15–25, 20–30
Hardness (Rockwell)	D785	—	—	R117–120	M50–65
Hardness (Shore)	D676	A50–100	A78–100	D70–85	>A95
Impact Str (Izod notched), ft-lb/in.	D256	Variable	Variable	0.25–1.2	2–8, 0.053
Mod of Elast in Flex, psi	D790	—	—	3.8–5.4 x 10^5	—
100% Modulus, psi		1300–1750	1200–2800	—	—
Flex Str, 1000 psi	D790	—	—	12.5–16	15–17, flexible
Compr Str, 1000 psi	D695	—	—	11–12	—
Compr Yld Str, 1000 psi	D695	—	—	10–11	75–85
Cold Flex Temp, F	D1043	−70 to 0	−7 to +59	—	—
Cold Bend Temp, F		−40 to −4	−49 to −4	—	—
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	1–700 x 10^{12}	4–300 x 10^{11}	10^{14}–>10^{16}	10^{14}–10^{16}
Dielec Str (short time), v/mil	D149	—	24–500	725–1400	—
Dielec Const (60 cycles)	D150	5.5–9.1	6.0–8.0	2.3–3.7	3–5
Dissip Factor (60 cycles)	D150	0.05–0.15	0.08–0.11	0.020–0.03	0.03–0.15
Loss Factor (60 cycles)	D150	—	1.0–1.2	0.030–0.072	—
FABRICATING PROPERTIES					
Bulk Factor		2.4–2.6	2.4–2.6	2.0–2.4	—
Compression Molding					
Pressure, 1000 psi		0.5–2	0.5–2	>1	0.5–5
Temperature, F		285–350	285–350	275–400	250–350
Injection Molding					
Pressure, 1000 psi		7–15	12–20	>20	10–30
Temperature, F		320–350	325–375	300–375	300–400
Mold Shrinkage, in./in.		0.02–0.05	0.02–0.06	0.001–0.004	0.008–0.012
Extrusion Temp, F		325–400	350–385	—	<375
HEAT RESISTANCE					
Max Rec Svc Temp, F		150–220	140–220	150–165	170–212
Heat Dist Temp, F					
66 Psi	D648	—	—	170–185	190–210
264 Psi	D648	—	—	140–170	130–150
Softening Point, F		—	—	—	240–280
CHEMICAL RESISTANCE		Generally resistant to alkalis and weak acids. Moderately to not resistant to strong acids. Not resistant to ketones and esters; aromatic hydrocarbons produce swelling			Excellent to all acids and most common alkalis[c]
USES		Parts made by molding, high speed extrusion, calendering. Blown extruded film. Vacuum cleaner parts, handlebar grips, doll parts, hair curlers, safety goggle cups, grommets, toy tires, garden hose, and protective garments	Parts made by calendering, extrusion. Insulation and jacketing for: communication and low tension power wire and cable, building wiring, appliance and machine tool cords, and switchboard cable	Parts made by calendering, laminating, molding, extrusion. Fume hoods and ducts, storage tanks, chemical piping, plating tanks, phonograph records. Sheets and shapes for decorative panels, other building uses	Extrusions: gasket rods, valve seats, flexible chemical tubing and pipe, tape for wrapping joints, chemical conveyor belts. Moldings: spray-gun handles, acid dippers, parts for rayon producing equipment

[a]Where two values or ranges are given, they represent unoriented and oriented forms, respectively.
[b]Modulus of elasticity in compression. [c]Unaffected by aliphatic and aromatic hydrocarbons, alcohols, esters, etc.

Polyvinyl Alcohol, Butyral and Formal—Molded, Extruded

Material →	ASTM	Polyvinyl Alcohol	Polyvinyl Butyral	Polyvinyl Formal
PHYSICAL PROPERTIES				
Specific Gravity	D792	1.21–1.31	1.08–1.12	1.20–1.25
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.46	—	0.089
Coef of Ther Exp, per °F	D696	$3.88–6.65 \times 10^{-5}$	$4.4–12.7 \times 10^{-5}$	$3.55–4.27 \times 10^{-5}$
Refractive Index	D542	1.49–1.53	1.48–1.49	1.49–1.505
Specific Heat, Btu/lb/°F		0.3	0.4	—
Transmittance (luminous), %		[a]	85–91	80–90
Water Absorption (24 hr), %	D570	>30	0.3–0.6	1.0–1.3
Flammability	D635	Slow burning	Slow burning	Slow burning
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	D638	—	$3.5–4.0 \times 10^5$	$5–7 \times 10^5$
Tensile Strength, 1000 psi	D638	1–5	4–8.5	9–11
Elongation (in 2 in.), %	D638	50–250	5–60	5–60
Hardness (Rockwell)	D785	—	L95	M80–90
Hardness (Shore A)		10–100	—	—
Impact Strength (Izod notched), ft-lb/in.	D256	—	1.2	0.4–2.0
Mod of Elast in Flex, psi		—	—	$5–6 \times 10^5$
Flexural Strength, 1000 psi	D790	—	10	13–18
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257	[b]	$>10^{14}$	—
Dielectric Strength (short time), v/mil	D149	[b]	—	860–1000
Dielectric Constant				
60 Cycles	D150	[b]	3.61	3.7
10^6 Cycles	D150	[b]	3.33	3.0
Dissipation Factor				
60 Cycles	D150	[b]	0.0070	0.007
10^6 Cycles	D150	[b]	0.0065	0.02–0.1[c]
FABRICATING PROPERTIES				
Compression Molding				
Pressure, 1000 psi		5–15	1–2	1–10
Temperature, F		250–300	320–400	275–325
Injection Molding				
Pressure		—	11–15	14–32
Temperature, F		—	400	325–425
Mold Shrinkage, in./in.		—	—	0.0015–0.0035
HEAT RESISTANCE				
Max Rec Svc Temp, F		—	115	130–165
Heat Dist Temp, F	D648	—	61.5	50–92
CHEMICAL RESISTANCE		Good resistance to organic solvents and petroleum. Attacked by strong acids. Softened or dissolved by weak acids and by alkalis	Resistant to alkalis, aliphatics, hydrocarbons. Slowly attacked by strong acids. Butyrals used with wider range of solvents than formals	Resistant to alcohols, esters, ketones, except those having high acetate content. Slowly attacked by strong acids
USES		Adhesives and binders, textile sizing, coating and sizing for paper, thickening agents. Molded: chemical and oxygen tubing, gaskets and diaphragms. Film: airtight bags, packaging for chemicals	Plasticized form used as interlayer for safety glass. Solution uses: adhesive primer, metal conditioner, cloth waterproofing, structural and printed circuit adhesive. Dispersion form: textile treatment, strip coatings, hot melt adhesives, wash primers	Base for electrical insulating enamel with high heat resistance. Metal wire and cable coatings requiring high toughness and adhesion. Structural adhesives

[a] Transparent to opaque.
[b] Under atmospheric conditions enough water will be absorbed to make most electrical measurements useless.
[c] At 10^3 cycles.

Acetal, Polycarbonate, Polypropylene, Chlorinated Polyether—Molded, Extruded

Material ➡	ASTM	Acetal	Polycarbonate[a]	Polypropylene	Chlorinated Polyether
PHYSICAL PROPERTIES					
Specific Gravity	D792	1.425	1.20	0.89–0.91	1.4
Ther Cond, Btu/hr/sq ft/°F/ft		0.13	0.11	0.08	—
Coef of Ther Exp, per °F	D696	4.5×10^{-5}	3.9×10^{-5}	6.2×10^{-5}	4.4×10^{-5}
Specific Heat, Btu/lb/°F		0.35	—	0.46	—
Water Absorption (24 hr), %	D570	0.12	0.35	0.03	0.01
Flammability, ipm	D635	1.1	Self-extinguishing	—	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	D638	4.1×10^5	3.2×10^5	$1.4–1.7 \times 10^5$	—
Tensile Strength, 1000 psi	D638	10.0	9.0–10.5	5.0	6
Elongation (total), %	D638	15	60–100	500–700	130
Hardness (Rockwell)	D785	M94, R120	M70, R118	R85–95	R100
Impact Strength, ft-lb/in.					
Notched	D256	1.4[b]	12–16	1.02	0.4
Unnotched	D256	20.0[b]	>60	>17	>33
Mod of Elast in Flex, psi	D790	4.1×10^5	3.8×10^5	$1.4–1.7 \times 10^5$ [c]	1.3×10^5
Flexural Strength, 1000 psi	D790	14.1	11–13	8.1[c]	5
Stiffness in Flex, 1000 psi	D790	4.1×10^5	—	114–142	—
Compressive Strength, 1000 psi	D695	5.2	11	—	—
Shear Strength, 1000 psi	D732	9.5	9.2	—	—
Yield Strength, 1000 psi	D638	10.0	8.0–9.0	4.3–4.9	—
Elongation (at yield), %	D638	15.0	5	10–20	—
ELECTRICAL PROPERTIES					
Volume Resistivity, ohm-cm	D257	$>4 \times 10^{13}$	2.1×10^{16}	6.5×10^{16}	1.5×10^{16}
Dielectric Strength (short time), v/mil	D149	500	400	769–820	400
Dielectric Constant					
60 Cycles	D150	3.7	3.17	—	3.1
10^6 Cycles	D150	3.7	2.96	2.0–2.1	2.92
Dissipation Factor					
60 Cycles	D150	0.004	0.0009	—	0.011
10^6 Cycles	D150	0.004	0.0100	0.0002–0.0003	0.011
Arc Resistance, sec	D495	129	120	—	—
FABRICATING PROPERTIES					
Bulk Factor	D1182	1.78	1.74	2.25	—
Injection Molding					
Pressure, 1000 psi		15–25	15–20	Wide range	10–20
Temperature, F		380–440	525–600	Wide range	440–465
Extrusion Temp, F		390–400	475–580	340–430	400–450
Mold Shrinkage, in./in.		0.025	0.005–0.007	0.015–0.030	0.004–0.008
HEAT RESISTANCE					
Max Rec Svc Temp, F		185	—	—	250
Heat Dist Temp, F					
66 Psi	D648	338	283–293	180–220	300
264 Psi	D648	212	280–290	130–140	185
Melt Pt (crystalline), F		347	514	330	—
CHEMICAL RESISTANCE		Excellent res to most organic solvents, including aliphatic and aromatic hydrocarbons. Not rec for use with strong acids and alkalis; should be tested for use with dilute acids and weak alkalis. Affected by ultra violet light	Insoluble in aliphatic hydrocarbons, ether and alcohols; partially soluble in aromatic hydrocarbons; soluble in chlorinated hydrocarbons; slowly decomp by alkaline substances. High stability to water and to mineral and organic acids	Res to most acids, alkalis and saline solutions, even at higher temp; res to organic solvents and polar substances. Above 175 F, soluble in such aromatic substances as toluene and xylene, and such chlorinated hydrocarbons as trichloroethylene	Excellent resistance to both inorganic and organic chemicals up to 250 F. Resistant to all inorganic acids except fuming nitric and fuming sulfuric
USES		Appliance parts. Gears, bushings, bearings, and movie projector and typewriter parts	Electrical parts, housings, structural parts, electronic components, telephone accessories	Structural shapes, housewares, electronic equipment, automotive parts	Valves, pump parts, tank linings, pipe, sheet and coatings for high temperature corrosive environments

[a] A glass-reinforced type is now available. [b] Injection molding compound. [c] Tinius-Olsen.

Ureas—Molded

Type ➔		1[a] (alpha cellulose-filled)	2[a] (cellulose-filled)	Woodflour-filled
PHYSICAL PROPERTIES	ASTM			
Specific Gravity	D792	1.47–1.52	1.52	1.45–1.49
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.17–0.244	—	—
Coef of Ther Exp, per °F	D696	$1.22–1.50 \times 10^{-5}$	—	—
Transmittance (luminous), %		21.8	0	—
Water Absorption (24 hr), %	D570	0.4–0.8	—	—
Flammability	D635	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	D638	$13–16 \times 10^5$	—	$11–14 \times 10^5$
Tensile Strength, 1000 psi	D638	5–10	—	—
Elongation (in 2 in.), %	D638	1.0	—	—
Hardness (Rockwell)	D785	E94–97, M116–120	—	M116–120
Impact Strength (Izod notched), ft-lb/in.	D256	0.24–0.35	0.26–0.275	0.25–0.35
Flexural Strength, 1000 psi	D790	10–18	10–13	7.5–12.0
Compressive Strength, 1000 psi	D695	25–38	—	25–35
Shear Strength, 1000 psi		11–12	—	—
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257	$0.5–5 \times 10^{11}$	$5–8 \times 10^{10}$	—
Dielectric Strength (short time), v/mil	D149	300–400	340–370	300–400
Dielectric Constant				
60 Cycles	D150	7.0–9.5	7.2–7.3	7.0–9.5
10^6 Cycles	D150	6.4–6.9	6.4–6.5	6.4–6.9
Dissipation Factor				
60 Cycles	D150	0.035–0.043	0.042–0.044	0.035–0.040
10^6 Cycles	D150	0.028–0.032	0.027–0.029	0.028–0.032
Loss Factor				
60 Cycles		0.24–0.38	0.30–0.32	0.24–0.38
10^6 Cycles		0.18–0.22	0.17–0.19	0.18–0.22
Arc Resistance, sec	D495	110–130	85–110	80–110
FABRICATING PROPERTIES				
Bulk Factor		2.4–3.0	2.5	2.2–2.5
Compression Molding				
Pressure, 1000 psi		2–8	2–5	2–8
Temperature, F		275–325	275–320	275–325
Mold Shrinkage, in./in.		0.006–0.014	0.007–0.008	0.006–0.014
HEAT RESISTANCE				
Heat Dist Temp, F	D648	266–280	—	270–280
CHEMICAL RESISTANCE		High resistance to organic solvents, oils and greases. Poor resistance to acids and alkalis, depending on concentration		
USES		Such housings as radio, business machines, food equipment. Toilet seats, household electrical switches and plugs, buttons, cosmetic containers and closures	Low cost items. Available only in dark color. Especially suited for electric switch plates, wiring devices and electrical parts requiring high arc resistance	

[a] ASTM D705.

Plastics Films

Type →	ASTM	Nylon 6	Polypropylene	Polyethylene Type I	Polyethylene Type II	Polyethylene Type III
GENERAL PROPERTIES						
Method of Production[a]		Extr	Extr, calndr	Extr, calndr	Extr, calndr	Extr
Forms Available		Sheets, rolls, tapes	Sheets, rolls, tapes	Sheets, rolls, tapes, tubes	Sheets, rolls, tapes	Sheets, rolls tapes
Clarity[c]		Trp	Trp	Trp, trl, opaque	Trp, trl, opaque	Trp, trl
Min Thickness, in.		0.0005	0.00075	0.00075	0.00075	0.00075
Max Width, in.		60	60	144	60	60
Area Factor, 1000 sq in./lb/mil[d]		24	30.7	30	30	29
PHYSICAL PROPERTIES						
Specific Gravity	D792	1.12	0.90	0.92	0.935–0.938	0.940–0.945
Ten Str, 1000 psi	D882	13.8–17.0	5–10	1.6–3.0	2.5–3.5	3.5–8.0
Elong, %	D882	>200	>200	200–800	>200	50–400
Burst Str (Mullen), psi[e]	D774	—	—	48	—	—
Tear Str (Elmendorf), gm/mil	D689	50	32–1760	100–300	93–97	10–350
Fold Endurance[g]	D643	Excellent	Excellent	Good	Good	Good
Heat Sealing Range, F[f]		400–450	325–350	250–375	250–375	250–375
Water Absorp (24 hr), %	D570	1.0–1.5	0.005 Max	Negligible	Negligible	Negligible
Water Vapor Perm, gm/100 sq in./24 hr[n]	E96	0.9–1.0 (1 mil)	0.06–0.10 (1 mil)	1.2–1.4 (1 mil)[e]	0.5–0.7 (1 mil)[e]	0.3–0.4 (1 mil)[e]
Gas Perm, cu cm/100 sq in./24 hr[e]						
Oxygen		6.5 (1 mil)	140 (1 mil)	550 (1 mil)	280 (1 mil)	200 (1 mil)
Nitrogen		—	—	180 (1 mil)	—	42 (1 mil)
Carbon Dioxide		—	—	2900 (1 mil)	990 (1 mil)	580 (1 mil)
CHEMICAL RESISTANCE						
Strong Acids	D543 or D1239	Poor	Excellent	Excellent[j]	Excellent[j]	Excellent[j]
Strong Alkalis		Excellent	Excellent	Excellent	Excellent	Excellent
Greases and Oils		Excellent	Very good	Fair	Fair	Fair
Solvents						
Ketone and Ester		Excellent	—	Good	Good	Good
Chlorinated		—	—	Fair	Fair	Fair
Hydrocarbon		Excellent	Very good	Fair	Fair	Fair
PERMANENCE						
Max Cont Svc Temp, F		380	300	200	230	250
Min Svc Temp, F		<−100	—	−68	<−100	<−100
Resistance to Sunlight		Fair	Fair	Fair	Fair	Fair
Dimensional Change, %		Nil	Nil	Nil	Nil	Nil
Storage Stability[k]		Excellent	Excellent	Excellent	Excellent	Excellent
Flammability (rate of burning)		Self-extinguishing	Slow	Slow	Slow	Slow

[a] Cast = casting; calndr = calendering; extr = extrusion; block = block process.
[b] ASTM D568.
[c] Trp = transparent; trl = translucent.
[d] Figures may vary with resin-plasticizer ratio.
[e] Properties particularly dependent on thickness.
[f] Unsupported film cannot be sealed on all types of heat sealers, since adhesion to metal sealer and distortion of film may be encountered.
[g] ASTM D643, Method A.
[j] Except nitric, fuming sulfuric and chlorosulfonic.
[k] Average warehouse conditions: 400–100 F, dry.
[l] Coating attacked.
[m] ASTM D643, Method B.
[n] At 95 F, 90% RH.

Plastics Films

Type →		Rigid Polyvinyl Chloride (incl copolymers)	Nonrigid Polyvinyl Chloride (incl copolymers)	Polyvinylidene Chloride (Saran)	PVC-Nitrile Rubber Blend	Polyvinyl Alcohol
GENERAL PROPERTIES	**ASTM**					
Method of Production[a]		Cast, calndr, extr	Cast, calndr, extr	Extr	Cast, calndr, extr	Cast
Forms Available		Sheet, rolls, tapes	Sheet, rolls, tapes, tubes	Rolls, tubes	Sheet, rolls, tapes, tubes	Rolls
Clarity[c]		Trp, trl, opaque	Trp, trl, opaque	Trp, trl, opaque	Trp, trl, opaque	Trp, trl
Min Thickness, in.		0.001	0.0005	0.0005	0.001	0.001
Max Width, in.		54	104	40	84	54
Area Factor, 1000 sq in./lb/mil[d]		19.5-22.5	20-23	16.3	22.8-23.7	21.6
PHYSICAL PROPERTIES						
Specific Gravity	D792	1.36-1.50	1.15-1.50	1.68	1.18-1.35	1.21-1.31
Ten Str, 1000 psi	D882	6.5-8.5	1-5	7-15	1.5-4.0	6-10
Elong, %	D882	5-25	50-500	25-40	250-500	400-600
Burst Str (Mullen), psi[e]	D774	—	9-20	30-70	—	185-235
Tear Str (Elmendorf), gm/mil	D689	20-150	30-1400	30	100-960	500-800
Fold Endurance[e]	D643	Poor	Good	500,000[g]	Excellent	Good
Heat Seal Temp Range, F[f]		260-400	200-400	285	220-350	300-400
Water Absorp (24 hr), %	D570	Negligible	Negligible	Negligible	Negligible	> 30
Water Vapor Perm, gm/100 sq in./24 hr[e]	E96	0.5 (0.005 in.) to 2.5 (0.001 in.)	0.7 (0.005 in.) to 8.0 (0.001 in.)	0.20	7.0	> 10
Gas Perm, cu cm/100 sq in./24 hr[c]						
Oxygen		3 (0.005 in.) to 15 (0.001 in.)	50-300[m]	0.56[m]	—	—
Nitrogen		—	—	0.11[m]	—	—
Carbon Dioxide		11 (0.005 in.) to 55 (0.001 in.)	250-2000[m]	2.4[m]	—	—
CHEMICAL RESISTANCE						
Strong Acids	D543 or D1239	Excellent	Excellent	Excellent[h]	Good	Poor
Strong Alkalis		Excellent	Excellent	Good[i]	Good	Poor
Greases and Oils		Good	Fair	Excellent	Excellent	Excellent
Solvents						
Ketone and Ester		Poor	Poor	Fair	Poor	Excellent
Chlorinated		Fair	Fair	Fair	Fair	Excellent
Hydrocarbon		Excellent	Good	Excellent	Good	Excellent
PERMANENCE						
Max Cont Svc Temp, F		200-220	150-180	290	200	—
Min Svc Temp, F		-70	-50	Good	-40	—
Resistance to Sunlight		Good	Good	Excellent	Fair	Excellent
Dimensional Change, %		Nil	Nil	Nil	Nil	High
Storage Stability[k]		Excellent	Excellent	Excellent	Excellent	Excellent
Flammability (rate of burning)		Self-extinguishing	Slow to self-extinguishing	Self-extinguishing	Slow to self-extinguishing	Slow

[a]Cast = casting; calndr = calendering; extr = extrusion; block = block process.
[c]Trp = transparent; trl = translucent.
[d]Figures may vary with resin-plasticiser ratio.
[e]Properties particularly dependent on thickness.
[f]Unsupported film cannot be sealed on all types of heat sealers, since adhesion to metal sealer and distortion of film may be encountered.
[g]ASTM D643, Method A.
[h]Except sulfuric and nitric.
[i]Except ammonium hydroxide.
[k]Average warehouse condition: 40-100 F, dry
[m]0.001-in. film.

continued on next page

Plastics Films

Type ➔		Fluorocarbon[a]	Polystyrene (oriented)	Polyester[b]	Cellophane	
					Plain	Coated
GENERAL PROPERTIES	**ASTM**					
Method of Production[c]		Block; extr	Extr	Extr	Extr	Extr
Forms Available		Sheet, tapes; sheet, tubes	Sheet, rolls	Sheet, rolls	Sheet, rolls, tapes	Sheet, rolls
Clarity[d]		Trp; trp, trl	Trp, trl, opaque	Trp, opaque; trp	Trp	Trp
Min Thickness, in.		0.002	0.001	0.00025	0.0009	0.0009
Max Width, in.		12; 20	40	55; 60	60	60
Area Factor, 1000 sq in./lb/mil[e]		13; 12	26.1	20; 22.6	21.5	19.5
PHYSICAL PROPERTIES						
Specific Gravity	D792	2.15; 2.11	1.05–1.07	1.39; 1.23	1.45	1.40–1.55
Ten Str, 1000 psi	D882	2–3; 6.3–6.6	7–12	17–28; 15–20	8–19	7–16
Elong, %	D882	200–250; 90–200	3–10	70–130; 40–80	15–25	15–50
Burst Str (Mullen), psi[f]	D774	—; 42	30–60	45; 56[i]	—	—
Tear Str (Elmendorf), gm/mil	D689	—; 200–350	2–8	18; 6	2–10	2–15
Fold Endurance[f]	D643	—; —	—	Excellent	7000–22,000	—
Heat Seal Range, F[g]		Not sealable; 415–450	220–300	490	Not sealable	200–350
Water Absorp (24 hr), %	D570	None	0.04–0.06	Negligible; 0.3	High	High
Water Vapor Perm, gm/100 sq in./24 hr[f]	E96	—; 0.00	6.2	1.8[i]	High	0.2–1.0
Gas Perm, cu cm/100 sq in./24 hr[f]						
Oxygen		—; 0.76[i]	213	5.7[i]; —	—	Low
Nitrogen		—; 5.5[i]	42	0.9[i]; —	—	Low
Carbon Dioxide		—; 8.0[i]	926	17.5[i]; —	—	Low
CHEMICAL RESISTANCE						
Strong Acids	D543 or D1239	Excellent	Good	Excellent	Poor	Poor
Strong Alkalis		Excellent	Excellent	Excellent	Poor	Poor
Greases and Oils		Excellent	Good	Excellent	Excellent	Good[j]
Solvents						
Ketone and Ester		Excellent	Poor	Excellent	Excellent	Poor[j]
Chlorinated		Excellent	Good	Excellent	Excellent	Excellent
Hydrocarbon		Excellent	Good	Excellent	Excellent	Fair
PERMANENCE						
Max Cont Svc Temp, F		565–585; 300–395	160–180	250; 300–360	375	300–375
Min Svc Temp, F		−90; −120	Good	−80	0	0
Resistance to Sunlight		Excellent	Fair	Fair	Good	Good
Dimensional Change, %		Nil	Nil	Nil	3–5	2–5
Storage Stability[h]		Excellent	Good	Excellent	Good	Good
Flammability (rate of burning)		Nil	Slow	Self exting; won't burn	Fast	Fast

[a] Two sets of figures are for TFE and CFE, respectively; where only one figure is given, it applies to both.
[b] Two sets of figures are for polyethylene terephthalate and poly (1, 4-cyclohexylene-dimethylene terephthalate), respectively; where only one figure is given, it applies to both.
[c] Cast = casting; calndr = calendering; extr = extrusion; block = block process.
[d] Trp = transparent; trl = translucent.
[e] Figures may vary with resin-plasticizer ratio.
[f] Properties particularly dependent on thickness.
[g] Unsupported film cannot be sealed on all types of heat sealers, since adhesion to metal sealer and distortion of film may be encountered.
[h] Average warehouse conditions: 40-100 F, dry.
[i] 0.001-in. film.
[j] Coating attacked.

Plastics Films

Type →			Cellulose				
		Rubber Hydrochloride	Acetate[m]	Triacetate (42.5-44% acetyl)	Acetate Butyrate[m]	Nitrate	Ethyl
GENERAL PROPERTIES	**ASTM**						
Method of Production[a]		Cast	Extr, cast	Cast	Extr, cast	Cast, block	Cast, block,
Forms Available		Sheet, rolls, tapes	Sheet, rolls, tapes, tubes	Sheet, rolls	Sheet, rolls	Sheet, rolls	Sheet, rolls, tapes
Clarity[c]		Trp, trl, opaque	Trp, trl, opaque	Trp	Trp, opaque	Trp, trl, opaque	Trp
Min Thickness, in.		0.0004	0.0005	0.003	0.0009	0.0005	0.003
Max Width, in.		60	60	45	40	50	30
Area Factor, 1000 sq in./lb/mil[d]		24	22	21.7	23.3	20	24
PHYSICAL PROPERTIES							
Specific Gravity	D792	1.12-1.15	1.25-1.35	1.28	1.16-1.18	1.42-1.46	1.14-1.16
Ten Str, 1000 psi	D882	5-6	9-14	9-11	6-9	10-11	6-10
Elong, %	D882	350-500	15-35	25-35	50-70	30-40	20-35
Burst Str (Mullen), psi[e]	D774	—	30-80	100-150	40-75	40-50	30-86
Tear Str (Elmendorf), gm/mil	D689	1000-1500	2-15	10-15	4-16	—	2-15
Fold Endurance[e]	D643	10^4-10^6	1500-2000[n]	200-300[n]	900-1300[n]	50-250[g]	2700
Heat Sealing Range, F[f]		225-350	400-500	—	—	—	—
Water Absorp (24 hr), %	D570	Negligible	Low	Low	Low	Low	Low
Water Vapor Perm, gm/100 sq in./24 hr[e]	E96	0.5-15.5	10-40	10	60	—	10-50
Gas Perm, cu cm/100 sq in./24 hr[e]							
Oxygen		2-405	3-6[m]	—	—	—	—
Nitrogen		—	—	—	—	—	—
Carbon Dioxide		36-2616	12-31[m]	—	—	—	—
CHEMICAL RESISTANCE							
Strong Acids	D543 or D1239	Good	Poor	Poor	Poor	Good	Poor
Strong Alkalis		Good	Poor	Poor	Poor	Fair	Excellent
Greases and Oils		Excellent	Good	Good	Fair	Fair	Good
Solvents							
Ketone and Ester		Fair	Poor	Poor	Poor	Poor	Poor
Chlorinated		Fair	Poor	Poor	Poor	Fair	Poor
Hydrocarbon		Excellent	Good	Good	Good	Fair	Fair
PERMANENCE							
Max Cont Svc Temp, F		205	250-300	300-400	200-250	140	210-275
Min Svc Temp, F		-20	-25	-25	-25	—	-75
Resistance to Sunlight		Fair	Good	Good	Good	Poor	Good
Dimensional Change, %		Slight	0.2-0.8	0.4	0.3	Nil	Slight
Storage Stability[k]		Good	Excellent	Excellent	Excellent	Fair	Excellent
Flammability (rate of burning)		Self-extinguishing	Slow, 70-100[b]	Self-extinguishing	Slow, 50-80[b]	Fast	Slow

[a] Cast = casting; calndr = calendering; extr = extrusion; block = block process.
[b] ASTM D568.
[c] Trp = transparent; trl = translucent.
[d] Figures may vary with resin-plasticizer ratio.
[e] Properties particularly dependent on thickness.
[f] Unsupported film cannot be sealed on all types of heat sealers, since adhesion to metal sealer and distortion of film may be encountered.
[g] ASTM D643, Method A.
[k] Average warehouse conditions: 40-100 F, dry.
[i] Coating attacked.
[m] 0.001-in. film.
[n] ASTM D643, Method B.

High Pressure Laminates (General Purpose)—Sheet, Rod, Tube

Grade →	CE (canvas-phenolic)	A (asbestos paper-phenolic)	AA (asbestos cloth-phenolic)	G-3 (glass cloth-phenolic)
PHYSICAL PROPERTIES				
Density, gm/cu cm	1.32	1.72	1.70	1.65
Ther Cond, Btu/sq ft/hr/°F/ft	0.17	—	—	—
Max Rec Svc Temp, F				
Short Time	300	400	400	410
Continuous	250	275	275	290
Coef of Ther Exp, 10^{-5} per °F				
Lengthwise	1.04	0.55	1.04	0.83
Crosswise	1.22	0.89	1.04	1.04
Water Absorption (24 hr), %				
1/16 In. Thick	1.3	1.3	2.5	1.8
1/8 In. Thick	0.9	0.8	2.0	1.2
1/2 In. Thick	0.5	0.5	1.2	0.7
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
Lengthwise	11	10	12	23
Crosswise	9	8	10	20
Flex Str, 1000 psi				
Lengthwise	22	20	21	32
Crosswise	17	18	19	28
Compr Str (flatwise), 1000 psi	39	40	38	50
Mod of Elast in Flex, 10^5 psi				
Lengthwise	9	23	16	15
Crosswise	8	14	14	12
Impact Str (edgewise), ft-lb/in.				
Lengthwise	1.6	1.0	4.5	7.5
Crosswise	1.4	0.9	4.0	6.0
Hardness (Rockwell)	M105	M111	M103	M120
Bond Strength, psi	2200	800	2000	1000
ELECTRICAL PROPERTIES				
Dielec Str (perp, short time), v/mil				
1/16 In. Thick	500	225	85	700
1/8 In. Thick	360	160	70	600
Dielec Str (par., step by step, 1/8 in. thick), kv				
Cond A	45	10	—	—
Cond D48/50	5	—	—	—
Dissip Factor (10^6 cycles)				
Cond A	0.055	—	—	0.030
Cond D24/23	0.070	—	—	—
Dielec Const (10^6 cycles, cond A)	5.3	—	—	6.5
Insulation Res (cond 35/90), megohms	—	—	—	200
Arc Resistance, sec	10	10	10	10
AIEE Insulation Class	A	B	B	B
USES	Switchboard panels, circuit breaker and switch arms, terminal blocks, electrode supports for plating tanks, bases for motors, bobbin heads (often in combination with XX)	Mechanical parts in drying ovens, tenter rails	Rotor vanes, water pumping thrust washers, armature slot wedges, caustic resistant applications, electric appliance insulation	Armature slot wedges, structural parts requiring good electrical properties, electrical equipment operating at relatively high temperatures

High Pressure Laminates (General Purpose)—Sheet, Rod, Tube

Grade →	G-5 (glass cloth-melamine)	G-10 (glass cloth-epoxy)	GPO-1 (glass mat-polyester)	Commercial and Trunk Fibre
PHYSICAL PROPERTIES				
Density, gm/cu cm	1.9	1.78	1.5-1.9	1.15
Ther Cond, Btu/sq ft/hr/°F/ft	0.29	—	—	—
Max Rec Svc Temp, F				
Short Time	425	350	350	—
Continuous	300	250	250	—
Coef of Ther Exp, 10^{-5} per °F				
Lengthwise	0.55	—	1.1	1.1
Crosswise	0.61	—	—	1.7
Water Absorption (24 hr), %				
1/16 In. Thick	1.0	0.09	1.0	66
1/8 In. Thick	0.6	0.06	0.70	61
1/2 In. Thick	0.4	0.03	0.35	36
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
Lengthwise	37	—	12	16
Crosswise	30	—	10	9
Flex Str, 1000 psi				
Lengthwise	65	72	23	18
Crosswise	50	63	20	15
Compr Str (flatwise), 1000 psi	70	—	40	30
Mod of Elast in Flex, 10^5 psi				
Lengthwise	17	—	15	—
Crosswise	15	—	13	—
Impact Str (edgewise), ft-lb/in.				
Lengthwise	12.0	14.4	12	2.3
Crosswise	9.0	10.6	10	2.1
Hardness (Rockwell)	M120	—	M93	R80
Bond Strength, psi	1700	2500	1000	—
ELECTRICAL PROPERTIES				
Dielec Str (perp, short time), v/mil				
1/16 In. Thick	600	810	650	200
1/8 In. Thick	500	570	500	195
Dielec Str (par., step by step, 1/8 in. thick), kv				
Cond A	32	55	60	—
Cond D48/50	12	60	33	—
Dissip Factor (10^6 cycles)				
Cond A	0.016	0.0119	0.03	—
Cond D24/24	0.030	0.0126	0.08	—
Dielec Const (10^6 cycles, cond A)	6.8	4.8	4.3	—
Insulation Res (cond C96/35/90), megohms	100	1×10^5	—	—
Arc Resistance, sec	200	100	140	80
AIEE Insulation Class	B	B	B	A
USES	Switchboard panels, arc barriers and circuit breaker parts, armature and slot wedges, structural parts, electrical applications requiring high strength and arc resistance, high temperature applications	Printed circuits; other applications where high insulation resistance and dimensional stability, are required.	Panel boards, slot wedges, spacers, coil blocking, layer insulation, core corner protectors, terminal plates, structural applications	Washers, terminal block covers, insulating plates and switch covers, arch supporters, bobbin and coil spool heads, arc barriers, shoe fiber, switch and appliance insulation, knee pads, golf club head plates, deep formed parts, trunks, cases, wastebaskets, mill boxes

High Pressure Laminates (Mechanical)—Sheet, Rod, Tube

Grade ➜	X (kraft paper-phenolic)	P (paper-plasticized phenolic)	PC (paper-phenolic)	ES 1, 2, 3 (paper base)*
PHYSICAL PROPERTIES				
Density, gm/cu cm	1.35	1.33	1.34	—
Ther Cond, Btu/hr/sq ft/°F/ft	0.17	0.17	0.17	—
Max Rec Svc Temp, F				
Short Time	275	275	250	—
Continuous	225	250	200	—
Coef of Ther Exp, 10^{-5} per °F				
Lengthwise	1.1	0.77	—	—
Crosswise	1.39	1.22	—	—
Water Absorption (24 hr), %				
1/16 In. Thick	4.0	2.2	3.2	2.5
1/8 In. Thick	2.3	1.5	2.0	1.8
1/2 In. Thick	0.9	—	—	—
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
Lengthwise	20	12	10.5	12-15
Crosswise	16	9	8.5	8-12
Flex Str, 1000 psi				
Lengthwise	28	15	14	15
Crosswise	23	13	11	15
Compr Str (flatwise), 1000 psi	36	25	22	—
Mod of Elast in Flex, 10^5 psi				
Lengthwise	18	12	10	—
Crosswise	13	9	8	—
Impact Str (edgewise), ft-lb/in.				
Lengthwise	0.9	0.8	0.9	0.25
Crosswise	0.7	0.6	0.8	0.22
Hardness (Rockwell)	M110	M90	M70	M118
Bond Strength, psi	900	—	—	—
ELECTRICAL PROPERTIES				
Dielec Str (perp, short time), v/mil				
1/16 In. Thick	700	650	600	—
1/8 In. Thick	500	470	425	—
Dielec Str (par., step by step, 1/8 in. thick), kv				
Cond A	—	50	—	—
Cond D48/50	—	10	—	—
Dissip Factor (10^6 cycles)				
Cond A	—	—	—	—
Cond D24/23	—	—	—	—
Dielec Const (10^6 cycles, cond A)	—	—	—	—
Insulation Res (cond C96/35/90), megohms	—	—	—	—
Arc Resistance, sec	10	—	—	—
AIEE Insulation Class	A	A	A	A
USES	Structural parts for radio, aircraft and electrical equipment and switchgear. Terminal boards or panels, insulating washers, bushings, coil forms, brush-holder bushings	Insulating washers, terminal boards, plug and socket bases, switch bases and panels for subassemblies	Motor and generator terminal boards, insulating washers, terminal strips, switch bases and panels, staked terminal boards and strips	Engraved name-plates, signs

*ES-1 is melamine laminate; ES-2 is phenolic laminate; ES-3 has phenolic core, melamine base.

High Pressure Laminates (Mechanical)—Sheet, Rod, Tube

Grade ➔	C (cotton canvas-phenolic)	L (cotton linen-phenolic)	MC (cotton fabric-melamine)	Bone Fibre
PHYSICAL PROPERTIES				
Density, gm/cu cm	1.35	1.34	1.5	1.3
Ther Cond, Btu/hr/sq ft/°F/ft	0.17	0.17	0.17	0.17
Max Rec Svc Temp, F				
Short Time	275	275	275	—
Continuous	225	225	225	—
Coef of Ther Exp, 10^{-5} per °F				
Lengthwise	1.04	0.77	—	1.1
Crosswise	1.22	1.04	—	1.7
Water Absorption (24 hr), %				
1/16 In. Thick	4.4	1.3	2.2	55
1/8 In. Thick	1.6	0.4	1.6	48
1/2 In. Thick	1.0	0.5	1.0	25
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
Lengthwise	11	14	11	17
Crosswise	9	10	7	10
Flex Str, 1000 psi				
Lengthwise	22	23	23	21
Crosswise	18	18	18	17
Compr Str (flatwise), 1000 psi	37	35	45	36
Mod of Elast in Flex, 10^5 psi				
Lengthwise	10	11	—	10
Crosswise	9	8	—	7
Impact Str (edgewise), ft-lb/in.				
Lengthwise	2.3	1.3	0.9	2.3
Crosswise	2.2	1.2	0.9	2.1
Hardness (Rockwell)	M103	M105	M115	R100
Bond Strength, psi	2000	1700	1900	—
ELECTRICAL PROPERTIES				
Dielec Str (perp, short time), v/mil				
1/16 In. Thick	500	500	—	200
1/8 In. Thick	360	360	—	200
Dielec Str (par., step by step, 1/8 in. thick) kv				
Cond A	15	15	—	—
Cond D48/50	—	—	—	—
Dissip Factor (10^6 cycles)				
Cond A	—	0.055	—	—
Cond D24/23	—	0.070	—	—
Dielec Const (10^6 cycles, cond A)	6.0	5.8	—	—
Insulation Res (cond C96/35/90), megohms	—	—	—	—
Arc Resistance, sec	10	10	100	100
AIEE Insulation Class	A	A	—	A
USES	Gears and pinions, cams, pulleys, bobbin heads, chemical piping and fittings, bearings	Small gears and pinions, parts requiring intricate machining, breaker arms, fairleads and knobs	Plating barrel applications; others requiring good resistance to caustics	Gears, cams, fairleads, bushings, grommets, switch handles, terminal blocks, armature slot wedges, threaded and tapped pieces

High Pressure Laminates (Electrical)—Sheet, Rod, Tube

Grade →	XX (paper-phenolic)	XXP (paper-phenolic)	XXX (paper-phenolic)	XXXP (paper-plasticized phenolic)	LE (cotton linen-phenolic)
PHYSICAL PROPERTIES					
Density, gm/cu cm	1.34	1.32	1.32	1.29	1.32
Ther Cond, Btu/hr/sq ft/°F/ft	0.17	0.17	0.17	0.17	0.17
Max Rec Svc Temp, F					
Short Time	300	275	300	275	300
Continuous	250	250	250	250	250
Coef of Ther Exp, 10^{-5} per °F					
Lengthwise	0.94	1.05	0.94	1.04	1.04
Crosswise	1.33	1.66	1.28	1.66	1.44
Water Absorption (24 hr), %					
1/16 In. Thick	1.3	1.3	0.8	0.40	1.3
1/8 In. Thick	0.9	0.9	0.5	—	0.8
1/2 In. Thick	0.5	—	0.3	—	0.5
MECHANICAL PROPERTIES					
Ten Str, 1000 psi					
Lengthwise	16	11	15	12	13.5
Crosswise	13	8.5	12	9.5	9.5
Flex Str, 1000 psi					
Lengthwise	18	18	18	21	18
Crosswise	14	14	14	15	15
Compr Str (flatwise), 1000 psi	34	25	32	25	37
Mod of Elast in Flex, 10^5 psi					
Lengthwise	14	9	13	11	10
Crosswise	11	7	10	8	8
Impact Str (edgewise), ft-lb/in.					
Lengthwise	0.55	0.55	0.5	0.5	1.3
Crosswise	0.50	0.50	0.45	0.4	1.2
Hardness (Rockwell)	M105	M100	M110	M110	M105
Bond Strength, psi	1100	—	1200	—	1800
ELECTRICAL PROPERTIES					
Dielec Str (perp, short time), v/mil					
1/16 In. Thick	700	700	650	1000	500
1/8 In. Thick	500	500	470	700	360
Dielec Str (par., step by step, 1/8 in. thick), kv					
Cond A	50	65	65	65	50
Cond D48/50	10	15	15	33	6
Dissip Factor (10^6 cycles)					
Cond A	0.040	0.037	0.034	0.027	0.048
Cond D24/23	0.046	0.045	0.038	0.030	0.058
Dielec Const (10^6 cycles, cond A)	5.3	4.5	4.7	4.27	5.3
Insulation Res (cond C96/35/90), megohms	60	500	1000	20,000	30
Arc Resistance, sec	10	10	10	10	10
AIEE Insulation Class	A	A	A	A	A
USES	Panels for switchboards and instruments, switch and circuit breaker arms, terminal blocks for motors and transformers, coil forms for radio and television, brush holder bushings, bobbin heads and spools	Condenser stator brackets, wave change switch rotors and stators, plug and socket bases, terminal boards and subpanels, insulating washers	Panels for radio and television equipment; jack spacers, radio coil forms, high voltage switchgear	Condenser stator brackets, wavechange switch rotors and stators, terminal boards and subpanels, coil support bases	Terminal blocks and strips, panels, high humidity applications

High Pressure Laminates (Electrical)—Sheet, Rod, Tube

Grade →	G-2 (glass cloth-phenolic)	G-6 (glass cloth-silicone)	G-7 (glass cloth-silicone)	N-1 (nylon fabric-phenolic)	Electrical Insulation Fibre
PHYSICAL PROPERTIES					
Density, gm/cu cm	—	1.65	1.68	1.15	1.20
Ther Cond, Btu/hr/sq ft/°F/ft	—	0.17	0.17	—	—
Max Rec Svc Temp, F					
Short Time	410	500	500	200	—
Continuous	290	400	400	165	—
Coef of Ther Exp, 10^{-5} per °F					
Lengthwise	—	0.56	—	—	1.1
Crosswise	—	0.55	—	—	1.7
Water Absorption (24 hr), %					
1/16 In. Thick	1.50	0.3	0.3	0.3	66
1/8 In. Thick	0.95	0.25	0.20	0.2	61
1/2 In. Thick	0.55	0.15	0.15	0.1	36
MECHANICAL PROPERTIES					
Ten Str, 1000 psi					
Lengthwise	16	13	23	8.5	21
Crosswise	11	10	18	8	10
Flex Str, 1000 psi					
Lengthwise	30	23	44	18	20.5
Crosswise	20	19	37	15	14.5
Compr Str (flatwise), 1000 psi	38	40	45	—	34
Mod of Elast in Flex, 10^5 psi					
Lengthwise	13	—	14	6	—
Crosswise	10	—	12	5	—
Impact Str (edgewise), ft-lb/in.					
Lengthwise	6.6	15.1	12.1	3.7	3
Crosswise	4.7	9.5	9.6	3.3	2.9
Hardness (Rockwell)	M110	M95	M100	M105	R70
Bond Strength, psi	1400	1000	800	1200	—
ELECTRICAL PROPERTIES					
Dielec Str (perp, short time), v/mil					
1/16 In. Thick	500	250	400	600	215
1/8 In. Thick	425	185	350	450	200
Dielec Str (par., step by step, 1/8 in. thick), kv					
Cond A	30	50	55	62	—
Cond D48/50	10	45	30	55	—
Dissip Factor (10^6 cycles)					
Cond A	0.025	0.0022	0.0015	0.024	—
Cond D24/23	0.080	0.0227	0.0150	0.030	—
Dielec Const (10^6 cycles, cond A)	5.5	4.18	3.9	3.3	—
Insulation Res (cond C96/35/90), megohms	5000	4000	2500	5×10^4	—
Arc Resistance, sec	—	220	220	—	125
AIEE Insulation Class	B	H	H	A	A
USES	Class B insulation; other applications where good temperature resistance is required but mechanical properties are not critical	Insulation applications where high temperature resistance, arc resistance and low losses are needed, such as Class H transformers	Radio transmitter parts; Class H transformers; low loss, high frequency radio and radar insulators; motor slot wedges; slot liners; top sticks	High voltage applications; radio wave change switch stators and rotors, where low losses are critical; electrical insulating parts that must be postformed	Armature slot insulation, armature end laminations; field coil insulation, metal box liners, washers, arc shields, formed slot wedges, gaskets, specialties

Glass-Reinforced Plastics (Low Pressure)—Molded Laminates [a]

Type →		Polyester (rigid styrene type)		Silicone-Woven Fabric	Epoxy-Woven Fabric
		Mat	Woven Fabric		
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.15–2.2	1.6–2.0	1.6–1.93	1.6–1.85
Coef of Ther Exp, 10^{-6} per °F	D325	1.0–1.4	—	—	—
Water Absorption (24 hr), %	D570	0.1–2.0	0.1–0.8	0.03–0.1	0.04–0.08
Flammability (<0.050 in.), sq in./min	D635	2.0 to self-exting	1.0 to self-exting	0–120[c]	—
MECHANICAL PROPERTIES					
Ten Str, 1000 psi	D638	8–25	25–55	20–40.6[d]	40–85
Hardness					
Rockwell	D785	M80–120	M100–120	—	M100–112
Barcol		40–55	55–65	50–75	62–66
Impact Str (Izod), ft-lb/in. notch	D256	7–15	13–18	—	12–18
Mod of Elast in Flex, 10^6 psi	D790	10–25	20–38	18–32[d]	30–46
Flex Str, 1000 psi	D790	20–40	40–75	23–47[d]	65–120
Compr Str, 1000 psi	D695	15–35	25–45	9.3–24[d]	45–52
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10^{11}	10^{11}	2.4–14 x 10^{14}	10^{16}
Dielec Str (short time, ⅛ in.), v/mil	D149	300–800	350–700	100–388	450–550
Dielec Const					
60 Cycles	D150	3.4–6.0	4.1–6.0	—	—
1000 Cycles	D150	3.4–5.8	4.0–5.8	—	—
10^6 Cycles	D150	3.4–5.6	3.8–5.6	3.5–3.97	4.2–4.9
Dissip Factor (10^6 cps)	D150	0.01–0.03	0.01–0.03	0.001–0.003	—
Loss Factor					
60 Cycles	D150	0.1–0.3	0.08–0.3	—	—
1000 Cycles	D150	0.07–0.3	0.06–0.3	—	—
10^6 Cycles	D150	0.03–0.2	0.03–0.2	—	0.05–0.09
Arc Resistance, sec	D495	90–130	90–180	225–250	130–185
HEAT RESISTANCE					
Max Rec Svc Temp, F		250–400	250–400[b]	450–500	250–400
Heat Dist Temp (264 psi), F	D648	200–550	390–550	—	—
CHEMICAL RESISTANCE		Slightly to heavily attacked by strong acids. Attacked by strong alkalis, ketones and chlorinated solvents		Satisfactory resistance to aviation gas, lube oils, 40% sulfuric acid, 5% hydrochloric acid, and Freon 114. Slightly attacked by 5% hydrochloric acid. Severely attacked by acetone, methyl ethyl ketone, ethyl alcohol, isopropyl ether, toluene, cellosolve, carbon tetrachloride, ethylene dichloride and trichlorethylene	Excellent resistance to organic liquids, such as alcohols and hydrocarbons. Resistant to weak acids and some strong acids. Slightly affected by some strong alkalis. Relatively poor general resistance to acetone, glacial acetic acid, 30% nitric acid and 30% peroxide
USES		Either mat, cloth or combination of both used, depending on strength and economic requirements. Represents largest volume of all low pressure reinforced plastics. Used for boats, car bodies and parts, aircraft parts, chairs, trays, skis, tote boxes, laundry tubs, machine housings, chemical storage tanks, architectural building panels		Special high temperature structural or electrical parts, such as aircraft radomes and ductwork, thermal and arc barriers, covers and cases for high frequency equipment	High strength parts, such as laminated tools for metal forming, aircraft structural parts, pipe, leaf or coil springs, high strength electrical or chemical resistant parts

[a] Range of values is intended only to indicate general order of magnitude. Specific properties vary widely with type and quantity of reinforcement resin formulation and fabricating practice.
[b] A TAC-polyester is now available for continuous use at 500 F.
[c] When tested according to method 2023 of Spec. MIL L-P-406.
[d] A primary attribute of silicones is good strength retention after continuous exposure to 450–500 F.

Plastics and Rubber Foams—Flexible

NATURAL RUBBER (LATEX)

Density, lb/cu ft	6.0-7.0
Ther Cond, Btu/hr/sq ft/°F/ft	0.021-0.025
Tensile Strength, psi	10-20
Max Rec Svc Temp, F	160
Flammability	Burns
Tear Strength, lb/in.	1.2
Resilience, %	64
Rebound, in.	2.5
Elongation, %	380
Compression Loss, %	
50,000 Flexes	13.0
300,000 Flexes	15.0
Compression Set, %	
22 Hr at 158 F	4.6
22 Hr at 177 F	4.1
Hysteresis Loss, %	23.2
RMA Compression, lb	30.0

POLYETHYLENE (CELLULAR)[a]

Tensile Strength	670
Elongation, %	310
Specific Gravity	0.47
Dielectric Strength, v/mil	
Short Time	220
Long Time	190
Dissipation Factor	
1000 Cycles	0.00033
10,000 Cycles	0.00038
Dielectric Constant	
1000 Cycles	1.48
10,000 Cycles	1.49

[a]Wire insulation for No. 14 AWG (0.250-in. o. d.). Wire insulation is the primary use of cellular polyethylene at present.

VINYL (OPEN CELL)

Density, lb/cu ft	4 and up
Heat Sealability	Excellent
Tensile Strength, psi	10-200
Elongation, %	75-300
Flammability	Self-extinguishing
Indentation Load	
Deflection (25% def)	
Original, lb/50 sq in.	3-500
After Aging, % chg[a]	±20
Compression Set (max, 2 hr at 158 F), %	15
Set after Dynamic Flexing (max, 250,000 cycles), %	10
Chemical Resistance[b]	
Strong Acids	E
Strong Alkalis	E
Grease, Oils	G
Organic Solvents	P to E
Water	E
High Humidity	E
Sunlight	G

[a]Air oven aging 22 hr, 212 F.
[b]E = excellent; G = good; P = poor.

SYNTHETIC RUBBERS

Type →	Neoprene	Butadiene-Styrene (GR-S)	Butadiene-Acrylonitrile
Density, lb/cu ft	10-30	4.5	10-25
Ther Cond, Btu/hr/sq ft/°F/ft	0.021-0.029	0.018	0.021-0.025
Tensile Strength, psi	20-100	80	40
Max Rec Svc Temp, F	180	160	210

URETHANES

Density[a] →	1	2-4	6-8	10-12	16-20
Yld Str (0.2% offset), psi	2.5	4-20	50-75	200	—
Compr Str (50% defl), psi	5	9-48	78-150	200-380	—
Coef of Ther Exp (−22 to 86 F) 10^{-5} per °F	—	1.4	—	—	5
Ther Insulation Coef (K)	0.20	0.20-0.21	0.22-0.23	0.26	0.28-0.30
Water Absorption, lb/cu ft					
25-Day Soak	28	22.8-24	—	—	2-4
120 Hr at 50% RH	0.005	0.006-0.027	—	—	0.067-0.084
120 Hr at 98% RH	0.38	0.38-0.39	—	—	0.359-0.560
Dielec Const (1000 cycles)	—	2.2-2.3	—	2.5	2.70-2.85
Vol Res, 10^{14} ohm-cm	—	6.8-6.9	—	7.2	7.7-8.3
Sound Absorption Coef					
250 Cycles	—	0.73	0.20	0.22	—
500 Cycles	—	0.33	0.22	0.21	—
1000 Cycles	—	0.37	0.20	0.31	—
Bond Str, psi					
Aluminum	6	10-27	—	56	158
Glass	5	9-25	—	50	142
Steel	7	12-29	—	62	146
Wood	8	17-29	—	62	170
Flame Res[b]					
2 Lb/Cu Ft	Incombustible				
10 Lb/Cu Ft	Self-extinguishing				
Max Rec Svc Temp, F	200				
Heat Dist Temp (5 psi flex, 0.10 in. defl), F	130				
Chemical Res	Swell slightly in many chemical solutions. Attacked by strong acids and alkalis				

[a]Density in lb per cu ft.
[b]Federal Bldg Spec SSA118A.

Plastics Foams—Rigid

SILICONES

Density[a] →	12[b]	14[b]	16[c]
Compr Str (orig), psi	100	200	325
Compr Str (after aging), psi[d]			
77 F, 200 Hr	100	190	210
500 F, 1/2 Hr	5	25	70
500 F, 200 Hr	20	45	80
Weight Loss During Expansion, %	1.2	1.3	1.0
Weight Loss After Heating, %			
1000 Hr, 500 F	3.5	2.6	2.6
1000 Hr, 570 F	8.0	4.2	4.2
72 Hr, 700 F	8.5	5.2	5.2
Water Abs (24 hr), %	3.2	2.3	2.1
Heat Dist Temp, F	>700	>700	>700
Flammability	No burn	No burn	No burn
Dielec Const (10^6 cycles)	1.23	1.25	1.26
Dissip Factor (10^6 cycles)	0.0004	0.00102	0.00105
Ther Cond, Btu/hr/sq ft/°F/ft	0.025	0.025	0.025

[a] Density in lb per cu ft.
[b] Expanded at 320 F.
[c] Prefoamed; expanded at 320 F.
[d] Heat aged at 500 F.

POLYSTYRENES AND CELLULOSE ACETATE

Type, Density[a] →	Polystyrenes				Cellulose Acetate (prefoamed)
	Prefoamed		Foam-in-Place		
	1.3-2.0	3.0-4.2	2-4	6-10	4-8
Compr Yld Str, psi	10–35	50–140	15–50[d]	60–100[d]	128–235
Ten Str, psi	30–100	105–185	30–85	90–130	112–183
Shear Str, psi	15–45	55–95	—	—	100–185
Flex Str, psi	>32	<170	40–120	130–310	73–177
Compr Mod of Elast, 1000 psi	0.45–1.75	1.7–5.3	—	—	5.5–13.5
Flex Mod of Elast, 1000 psi	0.20–1.9	—	—	—	3.5–5.5
Impact Str (Izod), ft-lb/in. notch	0.5–2.7	—	2.0–3.0[e]	3.0–5.5[e]	0.01–1.15
Flammability, ipm	Available self-ext		—	—	4.2–8.5
Ther Cond, Btu/hr/sq ft/°F/ft	0.020–0.024		0.018–0.019	0.020–0.023	0.025–0.027
Coef of Ther Exp, per °F	2.5×10^{-5}		—	—	$2.0\text{–}2.5 \times 10^{-5}$
Spec Ht, Btu/lb/°F	0.27		—	—	—
Max Rec Svc Temp, F	155–175		185	185	200–350
Water Absorption (vol), %	<6		—	—	0.15, 1.05[b]
Water Vapor Transmission[c]	1.5–3.0		—	—	—
Dielec Const	<1.07		1.19[f]	—	1.10–1.12
Dissip Factor	<0.004		>0.0005[g]	—	0.002–0.003

[a] Density in lb per cu ft. [b] Absorption in lb per cu ft at 50 and 100% RH, respectively
[c] Grains/sq ft/hr/in. Hg. [d] At 5% offset. [e] Unnotched, in.-lb/in.
[f] At 4–6 lb/cu ft density. [g] At 2–10 lb/cu ft density.

EPOXIES, PHENOLICS AND URETHANES[a]

Type, Density[b] →	Epoxy (prefoamed)		Phenolic (foam-in-place)		Urethane (foam-in-place)			
	5-10	13-20	2-5	7-10	0.5-5	6-9	12-15	18-25
Compr Str, psi	90–260	440–1080	9–31	45–130	2–120	150–250	350–800	900–1800
Ten Str, psi	51–180	360–650	4–35	35–75	10–150	150–300	300–600	700–1200
Flex Str, psi	210–420	570–940	24–40	75–230	—	—	—	—
Shear Str, psi	—	—	8–30	40–135	2–100	120–200	180–550	7600
Ther Cond, Btu/hr/sq ft/°F/ft	0.022	0.024	0.020	0.023	0.01–0.03	0.012–0.03	0.014–0.03	0.015–0.03
Coef of Ther Exp, 10^{-5} per °F	2.2	1.6	—	—	1.5	2.0	4.4	5.0
Water Abs (vol), %	0.25–1.3	0.09–0.1	—	—	—	1.6	0.6	0.2
Max Rec Svc Temp, F	—	—	300[c]	300[c]	250	350	400	400
Flammability	—	—	Noninflammable		Self-extinguishing			
Dissip Factor	0.0001–0.0004	0.003–0.009	—	—	0.0005	0.001	0.002	0.003
Vol Res, ohm-cm	—	—	—	—	—	—	—	—
Dielec Str, v/mil	—	—	—	—	—	—	—	—
Dielec Const	1.19–1.36	1.46–1.55	—	—	1.05	1.15	1.25	1.40

[a] Chemically activated. [b] Density in lb per cu ft. [c] For intermittent exposure: 550 F.

Hard Rubber—Molded, Extruded

Type →	Molded Parts[a]								
	GP	GP	GP	GP	H Ht	H Ar	Ar Ht Wr, H DQ	H Ht, Ch	Ht Ma
PHYSICAL PROPERTIES[b]									
Specific Gravity	1.21	1.21	1.28	1.54	1.65	1.95	1.71	1.24	1.80
Water Absorption (24 hr), %	0.08	0.06	0.14	0.30	0.06	0.06	0.10	0.12	0.04
Color	Black	Black	Black	Black	Red-brown	Red-brown	Red-brown	Black	Black
MECHANICAL PROPERTIES									
Ten Str, 1000 psi	8.3	7.9	4.5	2	6.75	4	5.8	7.17	5.4
Elong (in 2 in.), %	4.00	4.00	3.40	2.00	2.60	1.00	2.60	2.70	1.80
Hardness (Rockwell)	B108-76	B107-91	B129-79	B103-27	B83-60	B65-41	B82-55	B115-85	B82-54
Hardness (durometer)	81-87	81-87	78-84	76-82	85-92	87-95	86-92	84-90	84-92
Impact Str (Izod notched), ft-lb/in.	0.48	0.45	0.45	0.27	0.35	0.32	0.38	0.41	0.34
Flex Str, 1000 psi	12.5	11.3	7.1	2.8	8.7	8.4	9.1	11.3	10
Heat Dist Temp, F	142	145	134	Low	283	300	246	275	295
ELECTRICAL PROPERTIES									
Dielec Str (60 cycles), v/mil	435	496	344	377	393	600	371	400	420
Dielec Const[c]	3.00	2.95	3.80	4.95	4.10	4.80	4.60	3.50	4.10
Dissip Factor[c]	0.8	0.7	1.2	2.8	1.2	2.5	1.2	1.6	1.8
Surface Res (74 F, 86% RH), megohms	4.8×10^5	$>10^8$	$>10^8$	5.08×10^5	5.32×10^5	—	4.46×10^4	2.0×10^3	8.02×10^4

Type →	Sheets[a]					Rods and Tubes[a]			
	GP	El[d]	H Ht	H Ht, Ch	St Fl, H DQ	GP	El	H Ht, Ch	St Fl, H DQ
PHYSICAL PROPERTIES[b]									
Specific Gravity	1.20	1.17	1.43	1.24	1.27	1.21	1.15	1.24	1.27
Water Absorption (24 hr), %	0.06	0.22	0.15	0.12	0.08	0.06	0.12	0.12	0.07
Color	Black	Black	Black	Black	Yellow-brown	Black	Black	Black	Yellow-brown
MECHANICAL PROPERTIES									
Ten Str, 1000 psi	9.3	2.55	7.4	7.17	7.45	9.7	3.6	7.17	6.5
Elong (in 2 in.), %	5.00	33.00	1.20	2.70	5.30	5.00	16.00	2.70	3.80
Hardness (Rockwell)	112-79	—	86-60	115-85	112-80	107-70	—	115-85	112-80
Hardness (durometer)	80-86	50-60	86-92	84-90	80-86	80-86	65-75	84-90	80-86
Impact Str (Izod notched), ft-lb/in.	0.48	0.51	0.53	0.41	0.50	0.48	0.48	0.41	0.52
Flex Str, 1000 psi	16.6	—	9.64	11.3	14.95	11.375	—	11.3	9.06
Heat Dist Temp, F	159	Low	221	275	150	163	Low	275	217
ELECTRICAL PROPERTIES									
Dielec Str (60 cycles), v/mil	487	437	613	400	415	524	512	400	374
Dielec Const[c]	2.95	3.00	3.25	3.50	3.70	2.90	3.15	3.50	3.60
Dissip Factor[c]	0.5	1.3	0.6	1.6	0.6	0.5	1.4	1.6	0.9
Surface Res (74 F, 86% RH), megohms	2.23×10^7	2.66×10^4	$> 10^8$	2.0×10^3	7.98×10^4	$> 10^8$	$> 10^8$	2.0×10^3	6.73×10^4

[a]GP = general purpose, H = high, HT = heat resistance, Ar = arc resistance, Wr = wear resistance, DQ = dielectric quality, Ch = chemical resistance, MA = low moisture absorption, El = elongation, St = strength, Fl = flow resistance. These designations are arbitrary abbreviations of principal properties and are not standard.

[b]Hard rubber in general has a thermal coefficient of linear expansion of 0.00004 per °F.

[c]Frequency: 1 kc-1 mc.

[d]Semihard.

Rubber—Molded, Extruded

Type ➔	Natural Rubber	Butadiene-Styrene (GR-S)	Butadiene-Acrylonitrile (nitrile)	Chloroprene (neoprene)	Butyl (isobutylene-isoprene)
PHYSICAL PROPERTIES					
Specific Gravity	0.93	0.94	1.00	1.25	0.90
Ther Cond, Btu/hr/sq ft/°F/ft	0.082	0.143	0.143	0.112	0.053
Coef of Ther Exp (cubical), 10^{-5} per °F	37	37	39	34	32
Electrical Insulation	Good	Good	Poor	Fair	Good
Flame Resistance	Poor	Poor	Poor	Good	Poor
Min Rec Svc Temp, F	-60	-60	0	-40	-50
Max Rec Svc Temp, F	180	180	250	240	300
MECHANICAL PROPERTIES					
Ten Str, psi					
Pure Gum	2500-3500	200-300	500-900	3000-4000	2500-3000
Black	3500-4500	2500-3500	3000-4500	3000-4000	2500-3000
Elongation, %					
Pure Gum	750-850	400-600	450-700	800-900	750-950
Black	550-650	500-600	450-650	500-600	650-850
Hardness (durometer)	A30-A90	A40-A90	A40-A95	A40-A95	A40-A90
Rebound					
Cold	Excellent	Good	Good	Very good	Bad
Hot	Excellent	Good	Good	Very good	Very good
Tear Resistance	Excellent	Fair	Good	Fair to good	Good
Abrasion Resistance	Excellent	Good to excellent	Good	Good	Good to excellent
CHEMICAL RESISTANCE					
Sunlight Aging	Poor	Poor	Poor	Very good	Very good
Oxidation	Good	Good	Good	Excellent	Excellent
Heat Aging	Good	Very good	Excellent	Excellent	Excellent
Solvents					
Aliphatic Hydrocarbons	Poor	Poor	Excellent	Good	Poor
Aromatic Hydrocarbons	Poor	Poor	Good	Fair	Poor
Oxygenated, Alcohols	Good	Good	Poor	Poor	Very good
Oil, Gasoline	Poor	Poor	Excellent	Good	Poor
Animal, Vegetable Oils	Poor to good	Poor to good	Excellent	Good	Excellent
Acids					
Dilute	Fair to good	Fair to good	Good	Excellent	Excellent
Concentrated	Fair to good	Fair to good	Good	Good	Excellent
Permeability to Gases	Fair	Fair	Fair	Low	Very low
Water Swell Resistance	Fair	Excellent	Excellent	Fair	Excellent
USES	Pneumatic tires and tubes; power transmission belts and conveyor belts; gaskets; mountings; hose; chemical tank linings; printing press platens; sound or shock absorption; seals against air, moisture, sound and dirt		Carburetor diaphragms, self-sealing fuel tanks, aircraft hose, gaskets, gasoline and oil hose, cables, machinery mountings, printing rolls	Flexible petroleum tubes and hoses, petroleum and chemical tank linings; electrical insulation in contact with oil, flashlight cases, electrical sockets, special truck tires	Truck and automobile tire inner tubes, airing bags for tire vulcanization and molding, steam hose and diaphragms, flexible electrical insulation

Rubber—Molded, Extruded

Type →	Polysulfide (Thiokol)	Silicone (polysiloxane)	Urethane (diisocyanate polyester)	Fluorinated Acrylic (dihydroperfluoro-butylacrylate)	Viton (vinylidene fluoride-hexafluoropropylene)
PHYSICAL PROPERTIES					
Specific Gravity	1.35	1.25	1.25	1.5	—
Ther Cond, Btu/hr/sq ft/°F/ft	—	0.11-0.12	—	—	—
Coef of Ther Exp (cubical), 10^{-6} per °F	—	67	—	—	—
Electrical Insulation	Fair	Excellent	Fair	Good	Excellent
Flame Resistance	Poor	Fair	Good	Good	Good
Min Rec Svc Temp, F	−60	−120	−65	0	−50
Max Rec Svc Temp, F	250	550	240	450	450
MECHANICAL PROPERTIES					
Ten Str, psi					
Pure Gum	>1000	600-1000	>5000	1200	>2000
Black	—	—	—	—	—
Elongation, %					
Pure Gum	450-650	60-400	540-750	300	>350
Black	—	—	—	300	—
Hardness (durometer)	A40-85	A40-85	A35-100	A55	A60-90
Rebound					
Cold	Good	Excellent	Bad	—	Good
Hot	Good	Excellent	Good	—	Excellent
Tear Resistance	Poor	Poor	Good	Poor	Fair
Abrasion Resistance	Poor	Poor	Excellent	Poor	—
CHEMICAL RESISTANCE					
Sunlight Aging	Very good	Excellent	Excellent[a]	Good	Excellent
Oxidation	Very good	Very good	Very good	Good	Excellent
Heat Aging	Fair	Outstanding	Excellent[a]	Good	Outstanding
Solvents					
Aliphatic Hydrocarbons	Excellent	Poor	Excellent	Excellent	Excellent
Aromatic Hydrocarbons	Excellent	Poor	Excellent[b]	Excellent	Excellent
Oxygenated, Alcohols	Very good	Fair	Poor	Good	Poor
Oil, Gasoline	Excellent	Fair	Excellent	Excellent	Excellent
Animal, Vegetable Oils	Excellent	Excellent	Excellent	Excellent	Excellent
Acids					
Dilute	Good	Excellent	Fair	Excellent[c]	Excellent
Concentrated	Good	Fair	Poor	Excellent[d]	Good
Permeability to Gases	Extremely low	Fair	Excellent	Fair	—
Water Swell Resistance	Excellent	Excellent	Excellent	Poor	Excellent
USES	Seals, gaskets, diaphragms, valve seat disks, flexible mountings, hose in contact with solvents, balloons, boats, life vests and rafts	Wire and cable covering, gaskets, tubing, diaphragms, vibration mountings, rollers, insulators, valve seats and closures	Fork lift truck wheels, airplane tail wheels, back-up wheels for turbine blade grinders, spinning cots for glass fiber, hydraulic accumulators, shoe heels	O-rings; V-rings; diaphragms; special applications involving contact with halogenated solvents, organic phosphates and carbon tetrachloride	Critical seals, gaskets, diaphragms, flexible mounts, coated fabrics, etc., for service in chemical and thermal environments

[a] Discolors, but no change in properties.
[b] For up to 80% aromatics.
[c] To diesters, 450 F.
[d] To fire resistant hydraulic fluids, 450 F.

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RAN

EFFECTIVE STRENGTH AT THE RIGHT COST

CHECK THE RANGE OF KEY PROPERTIES OF TYPICAL LUSTRAN FORMULATIONS:

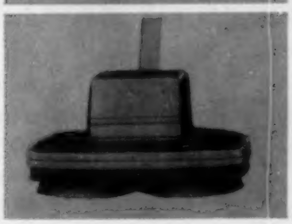
PROPERTIES	TEST CONDITIONS	UNITS	MOLDING FORMULATIONS 210	MOLDING FORMULATIONS 710	EXTRUSION* FORMULATIONS 261	EXTRUSION* FORMULATIONS 761	ASTM
Tensile							
Stress at Yield	73° F.	psi	9,000	6,200	6,800	5,100	D638-58T
Stress at Failure	73° F.	psi	6,800	5,200	6,200	4,500	D638-58T
Elongation at Yield	73° F.	%	3.3	3.2	2.2	2.5	D638-58T
Elongation at Failure	73° F.	%	45**	70**	25	40	D638-58T
Modulus in Tension	73° F.	psi	420,000	300,000	380,000	290,000	D638-58T
Impact Strength							
Izod ½″ x ½″ Bar Mld. (.010″ Notch Radius)	73° F.	ft. lbs./in. of notch	1.1	4.3	0.9†	3.6	D256-56
	0° F.	ft. lbs./in. of notch	0.8	2.0	0.6†	1.5	D256-56
	−40° F.	ft. lbs./in. of notch	0.6	1.4	0.6†	1.1	D256-56
Izod ⅛″ x ½″ Bar Mld. (.010″ Notch Radius)	73° F.	ft. lbs./in. of notch	1.3–4.0	6.0–8.5			D256-56
	0° F.	ft. lbs./in. of notch	0.7–1.2	2.0–2.6			D256-56
	−40° F.	ft. lbs./in. of notch	0.6–0.8	1.1–1.8			D256-56

*Data on Extruded Sheet **Monsanto Test †½″ x 0.115″ Bar-Sheet

Lustran's combination of light weight, superior toughness and rigidity, excellent thermal stability, colorability, gloss, and abrasion and chemical resistance provides new opportunities for creative industrial design.







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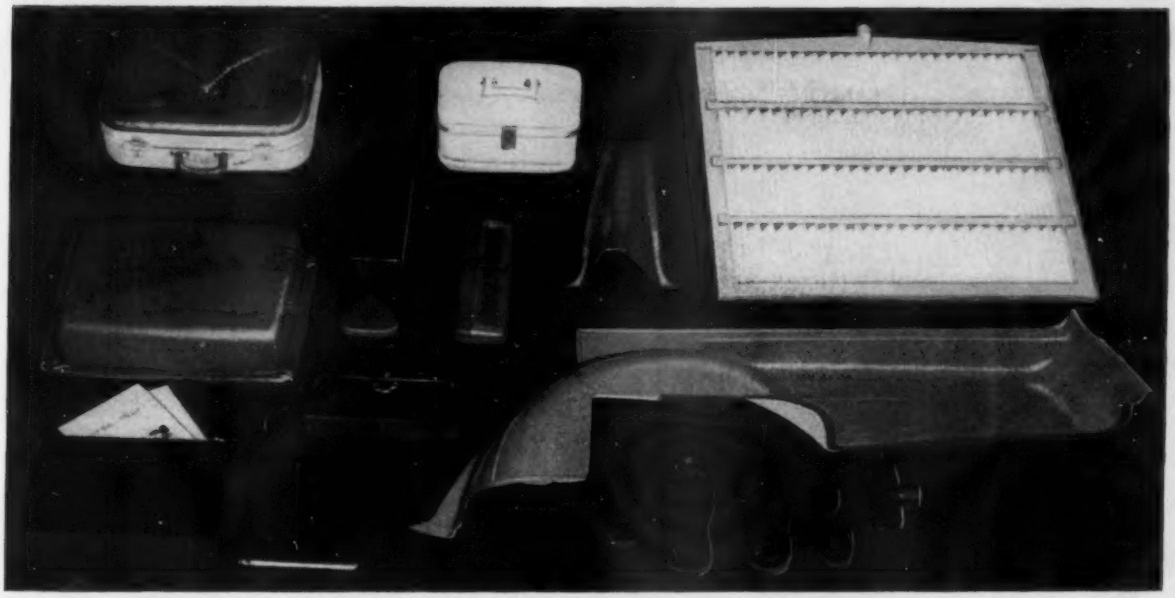

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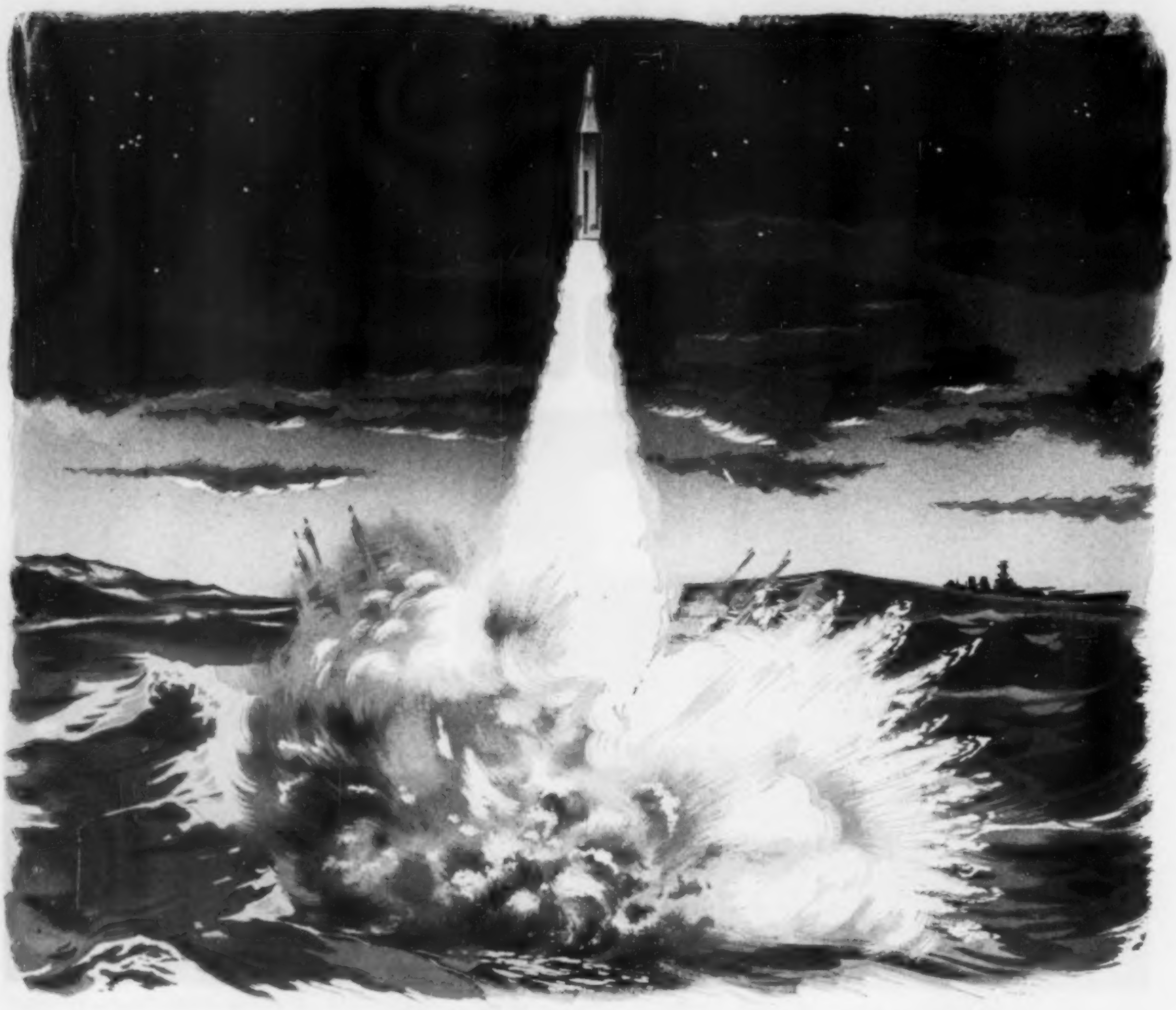
MOhawk 2-0311

Laboratory Research • Engineering • Injection Molding • Machining • Integrated to offer Every Service and Every Facility for Creating America's No. 1 Plastic Products

For more information, turn to Reader Service card, circle No. 416



R/M ASBESTOS-PHENOLICS

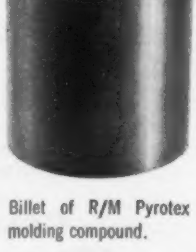
molded stock saves tooling up for prototype parts

Why pay for expensive dies and equipment for molding high-temperature test parts of reinforced plastics? Machine them from standard rods and tubes available from R/M in a broad range of sizes.

R/M asbestos-phenolic molding compounds have proved themselves in the hot spots of virtually every U.S. missile. They exhibit uniform ablation at extreme temperatures for nose cone or rocket engine environments. And they assure high strength-to-weight ratio, structural integrity and shock resistance, and low thermal conductivity and diffusivity.

The superiority of R/M Pyrotex® molding compounds stems from the use of extra-long spinning grade asbestos fibers.

You can rely on R/M technical data and engineering help. Send for details.



Billet of R/M Pyrotex molding compound.

R/M

RAYBESTOS-MANHATTAN, INC.

Reinforced Plastics Department, Manheim, Pa.

SPECIALISTS IN ASBESTOS, RUBBER, ENGINEERED PLASTICS, SINTERED METAL

For more information, turn to Reader Service card, circle No. 435

NEW FROM DU PONT...
a thermoplastic "Teflon" film that's easy to fabricate

TEFLON® FEP FILM

New "TEFLON"* FEP-fluorocarbon film has nearly *all* the unique advantages of "TEFLON" TFE with one big plus. It's a true thermoplastic that can be easily formed and sealed. One type of this new film can be applied *with* adhesives, another can be laminated and heat-bonded *without* them.

Here are just some of the advantages of "TEFLON" you get in this new film • Unique antistick and low-friction properties • Chemically inert to practically all known chemicals • Electricals are high (up to 4,000 volts/mil dielectric strength) and *stay* high • Performance stays virtually constant from -250°C. to over 200°C.

"TEFLON" FEP film opens the door to whole new areas of design and product improvement. Mail coupon and start investigating "TEFLON" FEP film for yourself. (Briefly describe the end use you have in mind.)

**Du Pont trademark*

DU PONT
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

E. I. du Pont de Nemours & Co. (Inc.)
Film Department 9531-N (T)
Wilmington 98, Delaware

Name____________________

Company Name____________________

Address____________________

____

Job Function____________________

Proposed End Use____________________

For more information, turn to Reader Service card, circle No. 383

ENJAY BUTYL

IS TOPS IN ALL —

RESISTANCE TO TEAR AND ABRASION

Enjay Butyl offers the highest aged tear strength of any rubber . . . even after long exposure to ozone and heat! Its inherent toughness resists abrasive wear, in such applications as tires, conveyer belts, hose and other mechanical goods.

RESISTANCE TO SUNLIGHT AND WEATHERING

Enjay Butyl has proven its resistance to ultra-violet light, ozone, oxidation, moisture and mildew. Increases life of products such as weatherstrips, garden hose, wading pools and automotive parts.

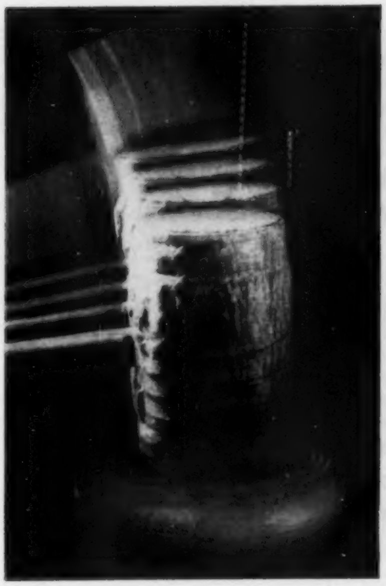
RESISTANCE TO CHEMICALS

Enjay Butyl, because of its unique and extremely low degree of unsaturation, offers excellent resistance to corrosive chemicals. The preferred rubber for tank linings, hose, seals, gaskets and other applications where exacting chemical resistance is required.

ELECTRICAL RESISTANCE

Enjay Butyl tops all vulcanizable rubbers in electrical and dielectric properties . . . in resistance to corona and ozone breakdown and water absorption. Its high dielectric strength insures against electric breakdown under normal or surge voltage. Its heat resistance permits higher current flow for a given conductor size.

RUBBER
'ROUND PERFORMANCE



DAMPING PROPERTIES

Enjay Butyl absorbs shock and vibrational energy more completely than any other rubber. Resiliency can be varied in compounding and processing. Butyl is ideal for axle and body bumpers, motor mounts and sound-deadening applications.

IMPERMEABILITY TO GASES AND MOISTURE

Enjay Butyl is tops in impermeability to gases and moisture . . . retains air pressure 8 times better than natural rubber. Outperforms other rubbers in such application as inner tubes, jar and bottle seals, hoses and inflatable goods.

OTHER BUTYL PRODUCTS

Enjay now offers three new Butyl products for use in design and production of quality end-products:

ENJAY BUTYL LATEX, an easy to handle emulsion that has all the properties of Butyl. Write the Enjay Home Office for a copy of our free Latex manual.

ENJAY BUTYL HT for any high-temperature application such as conveyor belts, electrical insulation materials, automotive break boots, etc.

VISTANEX®, an odorless, tasteless, non-toxic polyisobutylene for adhesives, caulking and sealingcompounds,resins,waxes,etc.

The outstanding properties of Butyl Rubber create new horizons for the designer, and offer to manufacturers an opportunity to utilize the qualities of rubber in applications never before possible. The unique properties of Butyl have led to vast improvement in many existing products. Technical skills will open the way to countless new uses.

Butyl is the "idea" rubber with uses stretching as far as the imagination can reach. We'll be glad to tell you all about it. Just contact Enjay at 15 West 51st Street, New York 19, New York.

Home Office: 15 West 51st St., New York 19, N. Y. Other Offices: Akron • Boston • Charlotte • Chicago • Detroit Area • Houston • Indianapolis • Los Angeles • New Orleans • Plainfield, N.J. • St. Louis Area • Tulsa.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

A DIVISION OF HUMBLE OIL & REFINING COMPANY

ENJAY®
BUTYL

For more information, turn to Reader Service card, circle No. 496

CIBA

Araldite® Epoxy Resin	Properties						Structural Uses									Coating Uses		
	epoxy value (eq./100 g.)	weight per epoxide (WPE)	weight per gallon (lb.)	color (Gardner)	melting point (Durran's) °C	viscosity (at 25°C.) Brookfield (cps.)	adhesives	casting	caulking and sealants	electrical	floor topping	impregnating	laminating	road toppings	tooling	maintenance	product finishing	trade sales
502	0.40-0.43	232-250	9.3-9.6	3 (max.)	(liquid)	2100-3600	●	●	●	●	●	●	●	●	●	●	●	
506	0.54-0.58	172-185	9.3-9.6	3 (max.)	(liquid)	500-700		●	●	●	●	●	●	●	●	●		
507	0.52-0.54	185-192	9.3-9.6	7 (max.)	(liquid)	500-700		●	●	●	●	●	●	●	●	●		
6005	0.53-0.55	182-189	9.6-9.8	3 (max.)	(liquid)	7000-10000	●	●	●	●		●	●		●	●		
6010	0.51-0.54	185-196	9.6-9.8	3 (max.)	(liquid)	12000-16000	●	●	●	●		●	●		●	●		
6020	0.48-0.51	196-208	9.6-9.8	3 (max.)	(liquid)	16000-20000	●	●	●	●	●	●	●					
6030	0.45-0.51	196-222	9.6-9.8	5 (max.)	(liquid)	25000-32000	●											
6040	0.36-0.43	232-278	9.6-9.9	5 (max.)†	——	Z4-Z6**	●									●		
6060	0.20-0.26	385-500	9.9 (av.)	4 (max.)†	60-75	——	●	●		●		●						
6071	——	425-550	9.9 (av.)	4 (max.)†	65-75	D-G†	●			●		●	●			●	●	●
6084*	——	875-1025	9.9 (av.)	4 (max.)†	95-105	R-U†										●	●	●
6097	——	2000-2500	9.8 (av.)	5 (max.)†	125-135	Z-Z2†						●					●	
6099	——	2500-4000	9.8 (av.)	5 (max.)†	145-155	Z2-Z5†											●	
7071	——	450-530	9.9 (av.)	4 (max.)†	65-75	D-G†	●			●		●	●			●	●	●
7072	——	550-700	9.9 (av.)	4 (max.)†	75-85	G-K†	●			●		●	●			●	●	●
7097	——	1650-2000	9.8 (av.)	4 (max.)†	113-123	X-Z†						●					●	

*Used primarily in conjunction with fatty acids to produce esters **Gardner-Holdt 90% N.V. in xylene †Gardner-Holdt 40% N.V. in butyl "Carbitol"

ARALDITE Epoxy Resin Solutions*

ARALDITE	405 HX	471 X	485 E	497 C	540 X	571 CX	571 K	571 KX	571 T	597 ET
non-volatile ±1.0%	50	75	50	55	90	80	70	75	75	55
viscosity (G.H.)	Z3-Z6	Z3-Z5	X-Z	Z3-Z5	Z4-Z6	Z5-Z7	W-Z	Z1-Z4	Z2-Z4	Z1-Z4
Room Temperature Systems:										
maintenance, marine and floor finishes		●				●	●	●	●	
specialty maintenance		●			●					
Baking Finishes:										
product finishes, primers, can and drum linings	●		●	●						●

* Solvent code: C = Cellosolve, E = Cellosolve acetate, H = Cyclohexanone, K = MIBK, T = toluene, X = xylene

In U.S.A. and Canada CIBA produces basic resins only to be formulated for intermediate and end uses.

For more information, circle No. 379

Further information on these CIBA products and applications may be obtained promptly by addressing:
CIBA Products Corporation
Fair Lawn, New Jersey

IF PHENOLICS CAN DO IT . . .

can answer your requirements for durability, strength, adaptability . . . can offer ease and economy of production and uniformity of quality . . . permit subminiature dimensions or relatively massive proportions . . . assure high precision, hardest wear, ability to withstand climatic, environmental, or special conditions . . . and make certain of satisfaction in product performance and appearance . . .

PLENCO

CAN PROVIDE IT . . .

from a wide range of dependable General-Purpose and Special-Purpose Molding Compounds . . . heat resistant, impact resistant, moisture, chemical, and electrical resistant compounds . . . non-bleeding compounds . . . mottles . . . colors . . . already made or custom-formulated to your needs, and available with Plenco's experienced counseling and testing services . . .

AND DOES

in countless, "hidden" industrial uses as well as attractive, "see me" consumer-product applications. There's a little Plenco (or quite a lot) in the best of things . . . and the best of companies put it there. Call us to discuss the advantages of Plenco phenolics for your product.

PLASTICS ENGINEERING COMPANY
SHEBOYGAN, WISCONSIN Serving the plastics industry in the manufacture of high grade phenolic molding compounds, industrial resins and coating resins.

For more information, turn to Reader Service card, circle No. 480

Celanese PLASTICS IN DESIGN

Celanese offers a variety of plastics that can improve the design and function of countless items

FORTIFLEX

A Complete Range of Polyethylenes

Available in all densities . . . natural or color-matched to your specifications. Four basic Fortiflex types for housewares, appliances, automotive, coatings, pipe, toys, film and sheet.

CELLULOSICS

Forticel—excellent balance of properties . . . toughness . . . dimensional stability . . . moldability. Acetate—rugged . . . versatile . . . economical. Both available in a variety of formulations, unlimited colors. The only thermoplastics combining both toughness and transparency plus economy.

INTRODUCING: CELCON ACETAL COPOLYMER

. . . a new engineering material offering advantages over metals

For years, Celanese market development specialists have recognized a widespread need for a material with good *moldability* and a high level of *performance*. Celanese research engineers, with long experience in polymer chemistry, have successfully designed and built a new copolymer—*Celcon*—which meets these exacting specifications.

As a *copolymer* of trioxane, Celcon has the chemical structure required for an exceptional *combination* of properties. It is the combination of engineering properties that makes Celcon the engineer's answer to many applications formerly requiring metals, thermosets, and other fabricating materials for performance. It is the combination of color, finish and easy molding for intricate shapes that make Celcon the *designer's* answer for eye appeal and function.

Celcon is specially designed to provide broad versatility in processing properties *without the usual sacrifice of high performance* in the end product. Celcon is truly a *new* plastic; not the usual molecular juggling of an existing material that improves one area of performance at the expense of another!

To have a high level of basic physical properties is one thing, but to develop these properties in commercial molding operations is frequently another. Polymer degradation during the molding operation can significantly reduce strength properties. Molded-in stresses can also reduce heat resistance as well as strength properties and chemical resistance.

Celcon's excellent flow characteristics, low-melting point, and wide molding temperature range permit commercial production of molded parts that are low in both polymer degradation and molded-in stress.

The effect on basic physical properties of molding over a temperature range of 100° F. is shown in Fig. 8. Essentially no polymer degradation is the result.

Commercially molded parts of good design generally will unmold between 310° and 315° F., just 5° below the softening temperature of Celcon. This is the proof-positive of low molded-in stress.

Another feature of Celcon's wide molding temperature range is that part dimensions are more readily controlled.

Celcon possesses the highly desirable characteristic of resisting further creep after the initial deformation. Or, simply, Celcon remains dimensionally *stable* over long periods of time, and under varying conditions of use. In this regard, it outperforms many other engineering plastics, especially at high temperatures.

Celcon, at the same time, is resistant to a very broad range of chemicals which could act as stress cracking and softening agents. This factor further reduces the possibility of unpredictable failures in a wide range of environments.

here's how* CELCON *performs for you . . .

1 Resists chemical attack
2 Resists temperature effects
3 Fights friction and abrasion
4 Stays strong and "springy"
5 Remains dimensionally and chemically stable
6 Resists impact
7 Offers good electrical properties
8 Provides a handsome surface

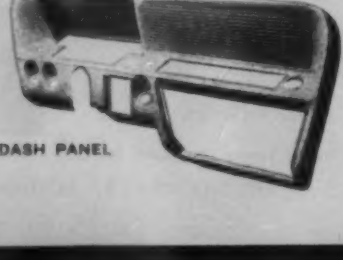
here are the applications for which Celcon is particularly suitable:

SLIDE RULE

DOOR HANDLES

BLOW MOLDED AEROSOL BOTTLE

DOOR HINGE



DASH PANEL

AUTOMOTIVE WATER PUMP

POLYESTER RESINS

Celanese polyester resins are outstanding for formulating and molding pre-mix and matched die preform parts. They offer fast cure, low drainage, better wet-out for hand lay-up. Save time and labor on critical large area moldings . . . boats, doors, truck bodies, housings.

CELLULOSIC FLAKES

Celanese offers cellulose acetate, cellulose triacetate and cellulose propionate flake in a variety of grades, to basic industries such as plastics, sheet, film, fibers, coatings and adhesives.

CELANESE Offers Service-in-Depth

Designed to help you make the best possible product at the lowest practical cost. Technically trained, experienced Celanese Representatives will gladly assist with any aspect of plastic selection, fabrication or application. They are backed by a line of quality plastic materials . . . specialists in design and molding techniques . . . and one of the newest and best equipped technical service laboratories, equipped to investigate a broad range of problems from new or improved plastic formulations to better shop techniques. And Celanese warehouses and facilities, strategically situated from coast to coast, can offer prompt delivery at any location.

FLEXURAL CREEP

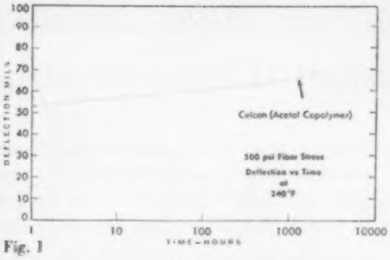


Fig. 1

At 240° F. Celcon follows a typical creep curve and at 3000 hours it is just under 3% total deflection. Data are the result of studies involving only stress, temperature and time. Under special environments the stability of Celcon is dramatically illustrated.

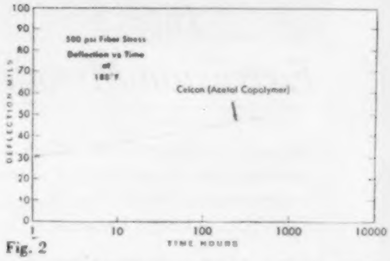


Fig. 2

Fifty mils deflection in this test represents 2½% deflection well within most product requirements.

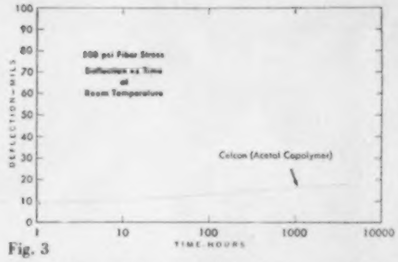


Fig. 3

Curve representing actual deflection versus time, plotted semi-logarithmic, at 73° F., Celcon performs well below 1% deflection after almost 5000 hours.

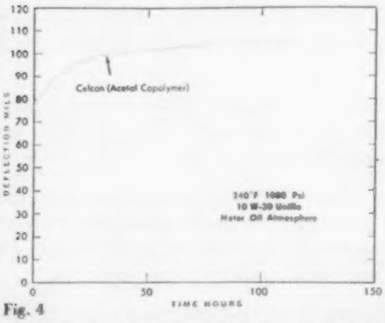


Fig. 4

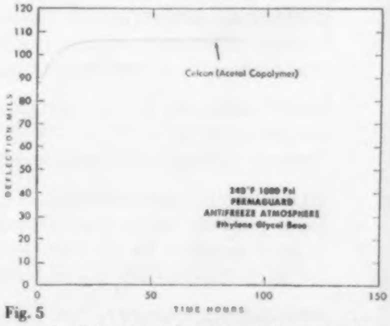


Fig. 5

The effect of environment added to creep behavior. Creep curve for Celcon is unaffected by antifreeze glycol or motor oil. The exceptional resistance of Celcon to so many organic compounds is a factor in lending predictability to its performance.

MOLDING PROPERTIES

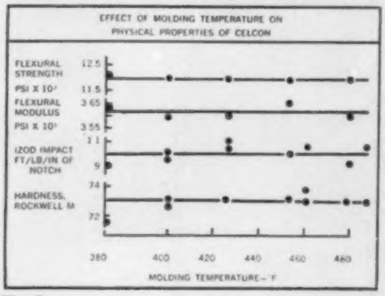


Fig. 8

In molding Celcon, over a plastic temperature range of 100° F., flexural strength and modulus, impact strength and hardness as well as other properties were not affected. Actually Celcon has been molded successfully from 350° F. to 485° F., a range of 135°. And its easy flow at these plastic temperatures permits lower temperatures in the mold. Mold temperatures from 140° F. to 240° F. have been used successfully.

EFFECT OF REMOLDING ON PROPERTIES CELCON COPOLYMER		1st MOLDING	5th MOLDING
TENSILE PROPERTIES			
YIELD STRENGTH	PSI	8800	8400
ELONGATION AT YIELD	%	12	12
TENSILE MODULUS	PSI X 10⁵	3.75	3.70
BREAK STRENGTH	PSI	8000	7600
ELONGATION AT BREAK	%	60	60
FLEXURAL STRENGTH, 5%	PSI	12000	12000
FLEXURAL MODULUS	PSI X 10⁵	3.65	3.65
IZOD IMPACT STRENGTH			
NOTCHED	FT - LB/IN		
73°F, 50% RH		1.1	1.1
-40°F			
UNNOTCHED—	FT - LB/IN	1.0	1.0
73°F, 50% RH		20	20
VICAT SOFTENING POINT	°C	160	160

Fig. 9

Comparison of ASTM properties of virgin Celcon with regrounds put through the molding operation five times. Across the profile of properties little significant difference is noted—a requirement for economical and predictable injection molding.

IMPACT RESISTANCE

Fig. 6

A steel ball dropping from the same height onto a panel of ordinary steel, .03" thick and onto a sheet of Celcon, .125" thick, but weighing less than the steel. The longer trajectory for Celcon is indicative of its comparative resiliency.

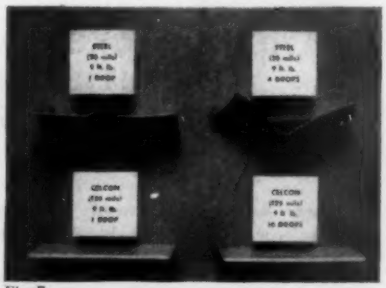


Fig. 7

The resultant deformation on the same two materials after one blow and a number of blows. Celcon sheets were impacted 10 times with no noticeable damage, but the steel panel was badly distorted after only 4 blows. The blow needed to *break* Celcon is well beyond the point at which many standard fabrication materials would have failed through distortion.

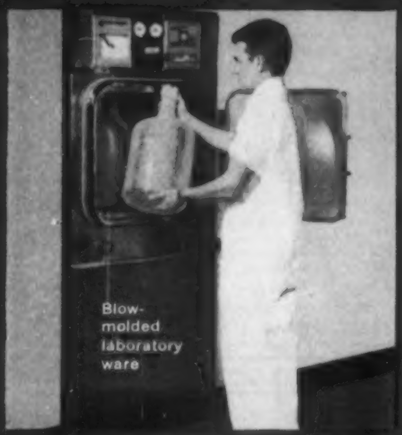
CELANESE POLYMER COMPANY

744 BROAD STREET,
NEWARK 2, NEW JERSEY

DIVISION OF CELANESE CORPORATION OF AMERICA
522 Fifth Avenue, New York 36, N.Y.
Canadian Affiliate: Canadian Chemical Company Limited, Montreal, Toronto, Vancouver
Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 522 Fifth Avenue, New York 36
Celanese® Fortiflex® Forticel® Celcon®

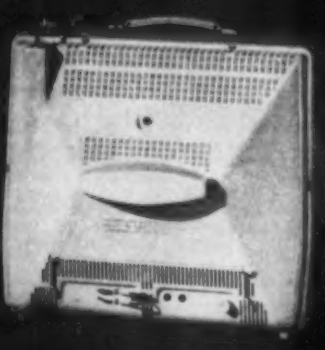
For more information, turn to Reader Service card, circle No. 502

Chairs are comfortable, durable, low cost



Blow-molded laboratory ware

Heat-resistant, takes intricate detail



Lint trap for automatic washer

AVISUN

Polypropylene

Full Range of grades for Injection Molding · Blow Molding Extrusion·Monofilaments·Thermoforming

AviSun polypropylene offers the designer and fabricator an impressive combination of properties at very low cost. Many products can be made better—and at lower cost than is possible with other thermoplastics, because of polypropylene's unusual balance of physical and mechanical properties.

HIGH HEAT RESISTANCE. AviSun polypropylene maintains its form stability well above 212° F. It is excellent for housewares, and products subjected to sterilization and autoclaving, and in structural applications where heat exposure renders other low cost thermoplastics unsuitable.

CHEMICAL RESISTANCE. Excellent resistance to acids, alkalies and most organic chemicals. Highly resistant to detergents, oils and greases. Stress cracking problems are non-existent.

LIGHT WEIGHT. AviSun polypropylene is the lightest of all plastics, with a specific gravity of .89 to .91. Because of its high yield per pound, it can compete economically with lower priced resins.

ELECTRICAL PROPERTIES. Outstanding electrical properties, combined with good mechanical and physical properties, make AviSun polypropylene a good material for the electrical industry. It is suited for wire coating, and for such components as coil forms, fuse sockets, distributor parts, etc.

UNIQUE FLEXIBILITY. The excellent flex-life of thin-walled sections enables the designer to use it as an integral hinge. Polypropylene integral hinges have been flexed as many as one million times without signs of failure. This unique property makes possible one-piece containers that include box, top, hinge and snap-catch. No costly assembly is required.

AVISUN BACKS YOU WITH COMPLETE FACILITIES AND SERVICES

Modern New Plant. The industry's newest and most modern production facilities assure adequate supplies, dependable uniformity and on-time shipments.

Research and Development. AviSun's large R&D organization is geared to continued leadership in the rapidly expanding field of thermoplastic technology.

Technical Service. AviSun specialists, expert in every fabrication technique, are available to help customers with their fabrication problems.

Marketing Assistance. AviSun's Market Development Group is constantly working with customers to develop new products and markets. In addition, AviSun carries on a broad advertising program to promote the advantages of products made from polypropylene.

Customer Service. AviSun maintains warehouses and sales offices throughout the country for fast delivery and efficient service.

For FURTHER INFORMATION, write for complete technical data.

best balance of CHEMICAL AND HEAT RESISTANCE TOUGHNESS · ECONOMY

TYPICAL PROPERTIES

AviSun #1014 General Purpose Injection Molding Grade

PROPERTY	UNIT	VALUE
	PHYSICAL	
Color	—	Translucent White
Bulk Factor	—	1.80 -2.00
Specific Gravity	gm/ml	0.905-0.915
Mold Shrinkage	in/in	0.010-0.020
	MECHANICAL†	
Yield Strength	psi, 2 in/min	5000
Ultimate Elongation	%, 2 in/min	200
Stiffness-Flexural	10^5 psi	1.8
Izod Impact	ft lb/in notch	1.0
Hardness	Rockwell R	90
	THERMAL	
Melting Point, Dilatometer	°F	345
Heat Distortion—66 psi	°F	240
Deformation Under Load—2000 psi 122°F, 24 hrs	%	3.1
Coefficient of Linear Expansion (0-150°F)	in/in/°F	6.7×10^{-5}
Specific Heat	Cal/gm/°C	0.45
Flammability		Slow
	GENERAL	
Water Absorption, 24 hrs	%	<0.01
Environmental Stress Cracking		None

†Injection molded samples, as molded.

AviSun offers a number of grades of polypropylene resins, each engineered for specific types of applications. AviSun technical service representatives can recommend the grade best suited for your application. Colored formulations of all grades are available with full AviSun warranty on a made-to-order basis. Economical color concentrates available for colored moldings or extrusions.

AVISUN*

*a trademark of AviSun Corp.

AVISUN CORPORATION

POLYMER PLANTS
New Castle, Del.

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1345 Chestnut Street
Philadelphia 7, Pa.
Telephone: LOcust 8-5520

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Los Angeles 5, Cal., Rm. 730, Texaco Bldg., 3350 Wilshire Boulevard

New York 22, N.Y., 460 Park Avenue

Orange, Texas, P.O. Box 1209

In Canada: Courtaulds Plastics Canada Limited

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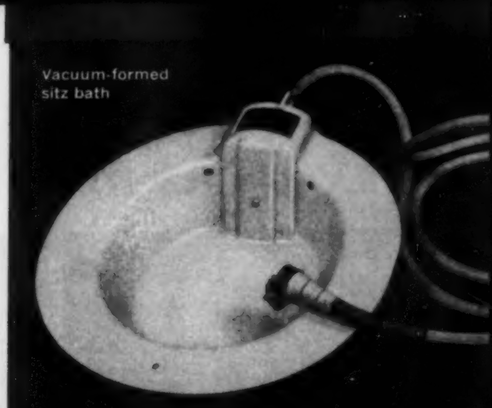
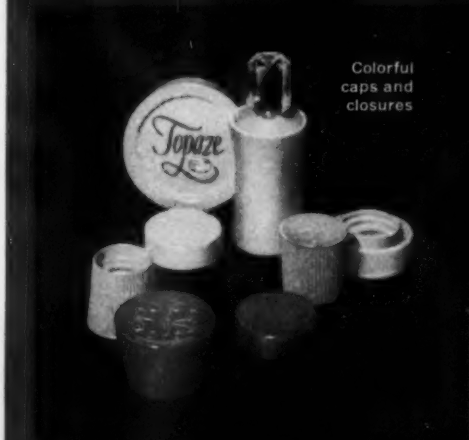

Vacuum-formed sitz bath

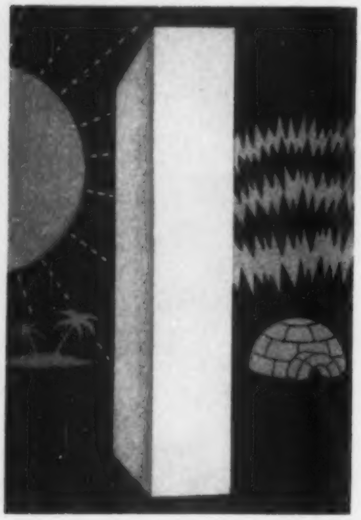

Shaver kit with self-hinge

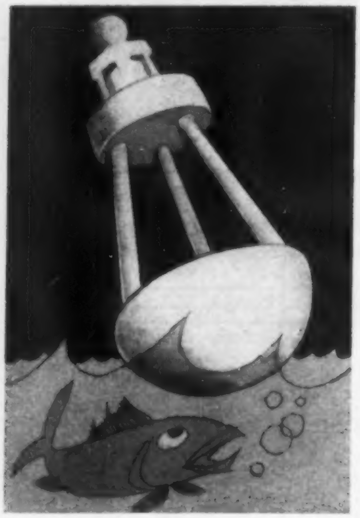


Colorful caps and closures


Monofilaments for rope, webbing and bristles

Five reasons why so many designers select





It's an insulator

The Thermal Conductivity (K Factor) of DYLITE is 0.242 at a 75°F. mean temperature at 2 lb./cu.ft. density. DYLITE resists heat, is unaffected by moisture condensate. Cooler chests molded of DYLITE keep food and beverages cold for days without ice refill. DYLITE is easily molded to fit contours of component parts of refrigerators, air conditioners and freezer cabinets.

It's waterproof

At 2 lb./cu.ft. density, DYLITE's rate of Water Vapor Transmission is 1.18 perms., and its rate of Water Absorption is 0.54 lbs./cu.ft. after 48 hrs. immersion. DYLITE is ideal for boats, rafts, buoys and other types of buoyant marine equipment. DYLITE remains in the water indefinitely without becoming water logged, and it is mildew-proof.

It's shock-resistant

DYLITE possesses an Energy Absorption ratio (Maximum Load) of 56.74 in. lbs./cu.in. at a density of 2 lb./cu.ft. For example, Royal electric typewriters are now shipped in shock-absorbent DYLITE packages—a result of performance tests in which DYLITE was proved superior to other materials for this job.

TYPICAL PROPERTIES OF DYLITE EXPANDABLE POLYSTYRENE—DENSITY 2 LB./CU.FT.
• Compressive Strength—30 Psi • Tensile Strength—55 Psi • Water Vapor Transmission—1.18 Perms.
• Water Absorption—0.54 Lbs./Cu.Ft. • Thermal Conductivity (K Factor)—0.242 at a 75°F. Mean Temperature
• Energy Absorption (Maximum Load)—56.74 In.Lbs./Cu.In.

DYLITE is a registered trademark of Koppers Company, Inc.

DYLENE® polystyrene, SUPER DYLAN® polyethylene and DYLAN® polyethylene are other fine plastics produced by Koppers Company, Inc.

Offices in Principal Cities • In Canada: Dominion Anilines and Chemicals Ltd., Toronto, Ontario

DYLITE® expandable polystyrene

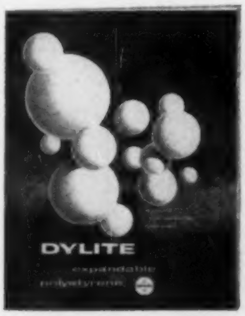
It's lightweight

Dylite is lighter than cork—it can be molded in densities of 1 to 10 lb./cu.ft. The advantages of light weight are obvious. In packaging, Dylite helps reduce shipping costs and makes handling easier. In the construction field, where Dylite is used as an insulator, its light weight means fast and easy installation.

It's strong

Dylite has a Compressive Strength of 30 psi and a Tensile Strength of 55 psi at a 2 lb./cu.ft. density. Dylite can be used to great advantage in a wide variety of industrial design problems. For instance, sandwich structures that employ Dylite as the core material offer high strength without sacrificing light weight.

. . . if you would like more information about versatile Dylite expandable polystyrene, write for this free booklet.

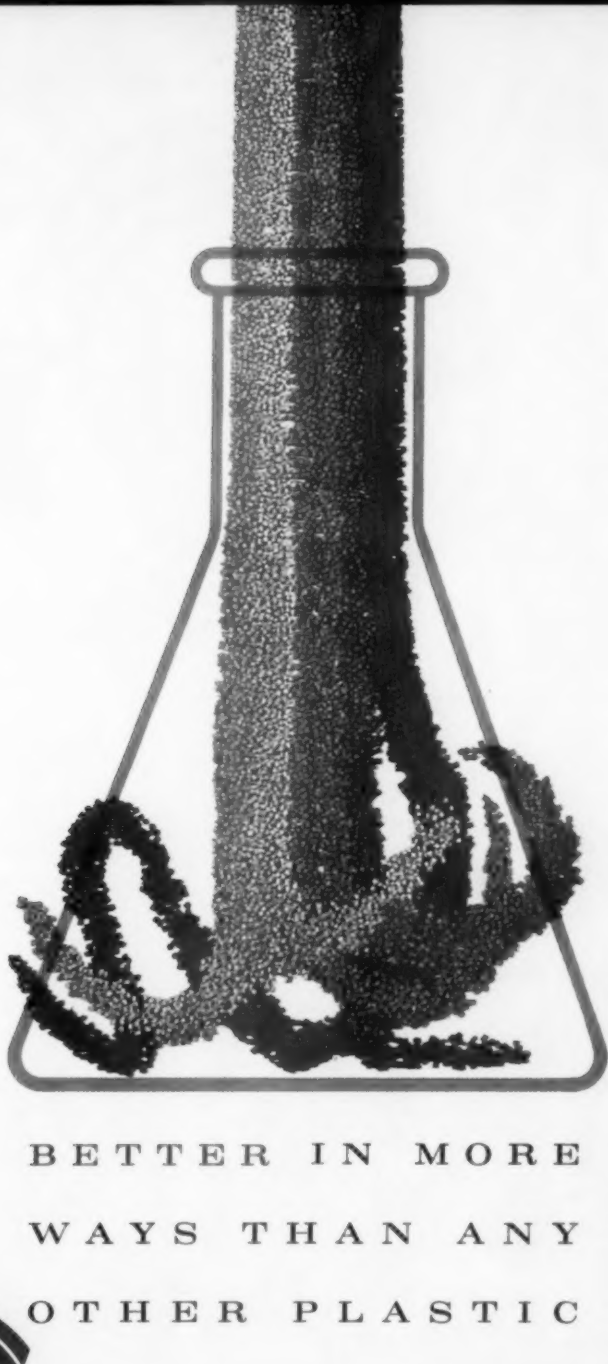


Koppers Company, Inc.
Plastics Division
Dept. 1535,
Pittsburgh 19, Pa.

For more information, turn to Reader Service card, circle No. 465

For more information, turn to Reader Service card, circle No. 386

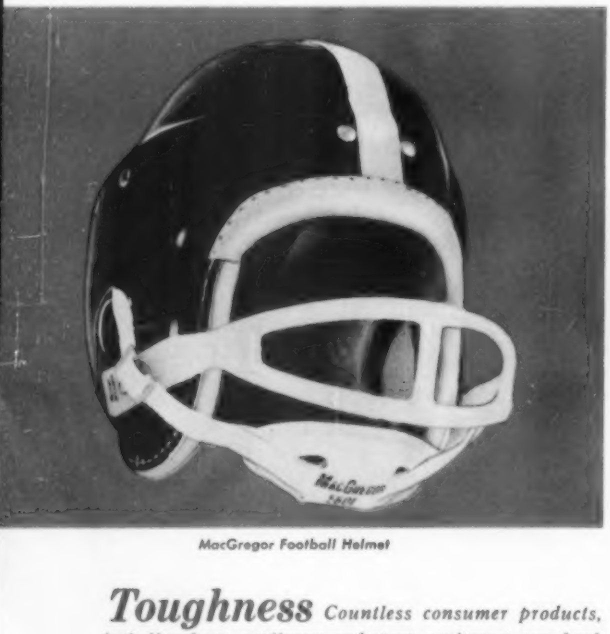
For more information, circle No. 529 ➤



Cyco

is the only plastic that excellence in all

CYCOLAC brand polymers is a unique family of ABS (acrylonitrile-butadiene-styrene) thermoplastic resins produced by the Marbon Chemical Division of Borg-Warner. Available in eleven major formulations, CYCOLAC brand plastic is especially well suited for a wide range of consumer and industrial applications. It can be readily injection molded, extruded or



MacGregor Football Helmet

Cell Director by Western Electric

Toughness *Countless consumer products, including home appliances and sports equipment, can thank the superior tensile strength and impact-resistance (even down to −40°F) of CYCOLAC brand resins for their rugged durability so vital to reliable service.*

Hardness *CYCOLAC brand polymers offer unusual hardness coupled with a satiny finish that retains its smooth, attractive appearance indefinitely, even under constant handling and use. Its ability to resist staining and withstand marring and scuffing makes it ideal for office machines and telephones.*

**CYCOLAC is the registered trademark of Borg-Warner for its family of ABS thermoplastic resins*

LAC®
BRAND

offers consistent three vital requirements!

vacuum formed into a super-rigid shell or a semi-flexible material—the range is almost infinite. In fact, the unique balance of mechanical, electrical and chemical properties offered by this truly versatile material can meet almost every manufacturer's design and engineering specifications!

Remington Standard Typewriter

Rigidity *Highly resistant to flexure strain, CYCOLAC brand plastic maintains its original shape under extreme load, even at high temperatures. Since it is also chemically resistant, it is ideally suited for such products as automobile dash panels, typewriter housings and luggage.*

CYCOLAC BRAND POLYMERS ALSO OFFER THESE SEVEN OTHER PRODUCT-IMPROVING ADVANTAGES:

GOOD ELECTRICAL PROPERTIES
The low water absorption rate of CYCOLAC brand ABS plastic plus its uniform dielectric constant and power factor are basic properties needed in many electrical applications.

RESISTANCE TO CHEMICALS
CYCOLAC brand plastic is highly corrosion-resistant and offers protection against alkalies, salt solutions, oils and mild acids—significant advantages in such industrial applications as ABS pipe, fittings, ducting and vent systems.

LIGHTWEIGHT
CYCOLAC brand ABS resins are the lightest of all the truly rigid thermoplastics, with a Specific Gravity as low as 1.02. This weight advantage can be transferred into more material per dollar spent by the manufacturer, as well as many consumer benefits.

WIDE COLOR RANGE
CYCOLAC brand plastic is available in literally hundreds of bright, sparkling colors, tints and shades. This wide color range, combined with its superior resistance to household stains (it defies fruit acids, even lipstick) adds lasting value to any end-use product.

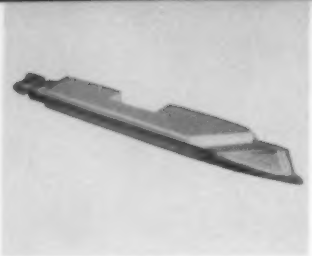
DIMENSIONAL STABILITY
CYCOLAC brand polymers offer excellent dimensional stability, even under extreme temperature conditions. This serviceability in severe heat or subzero cold plus a low water absorption rate makes CYCOLAC brand plastic ideal for such products as precision gears and housings.

HIGH GLOSS FINISH
CYCOLAC brand ABS polymers mold to a luxurious satiny finish that protects as it decorates. The smooth, hard surface resists scratching and marring and retains its natural sheen for the life of the application.

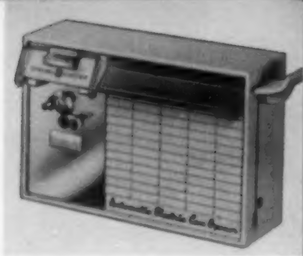
EASE OF FINISHING
Products made of CYCOLAC brand polymers can be calendered into a grained, leather-like finish; take lacquering, enameling or printing; are readily vacuum metallized; and can be easily laminated or solvent bonded.

Instrument Clusters

Air Conditioners



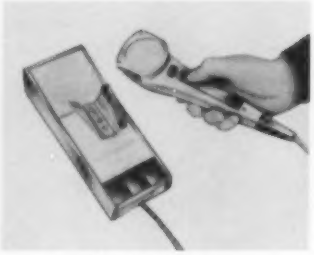
Arm Rests



Can Openers

Refrigerator Door Liners

Transistor Radios



Dictating Machines

Compact Telephones

Transistor Radios

Portable Typewriters

Postal Sorting Trays

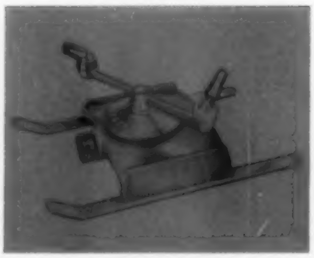
Photo Copy Machines

APPLICATIONS

EVERY LEADING INDUSTRY IS NOW
OF THE DESIGN, ENGINEERING,
PERFORMANCE IMPROVEMENTS

Ride-On Mower Cars

Lawn Sprinklers



Rotary Lawn Mowers

Spincasting Reels

Pipe & Fittings

Shoe Heels

Toboggan Sleds

Food Carriers

Blenders

Floor Washer Attachments

Wall Telephones

Two-Way Radios

Chair Arm Rest & Kick Plate

Adding Machines

In production and in application, CYCOLAC brand ABS polymers are proving their merits in a rapidly growing list of consumer and industrial products. From telephones to refrigerator car liners, lawn mowers to radar antennas, this remarkable family of Borg-Warner materials is helping molder and manufacturer alike to produce products that look better, sell easier and last longer. CYCOLAC brand plastic is not just another plastic . . . it is an engineering material that should be considered for metal as well as plastic applications. Easy to mold or fabricate, its unique balance of properties gives the designer new creative freedom; productionwise, it opens the door to manufacturing economies never before possible with other materials. Small wonder, then, that leading manufacturers all across the industrial spectrum are discovering that only CYCOLAC brand plastic combines so many properties . . . offers so many opportunities . . . does so many things so well!

UNLIMITED

TAKING ADVANTAGE
PRODUCTION AND
OFFERED BY →

CYCOLAC®
BRAND

POLYMERS

√ ***Easy to mold***

√ ***Easy to extrude***

√ ***Easy to vacuum form***

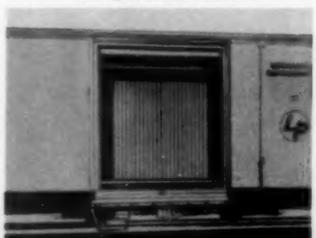
Air Conditioning • Automotive • Communications • Domestic and Commercial Refrigeration • Electrical • Footwear • Hardware & Housewares • Home Appliances • Industrial Pipe & Fittings • Lawn & Garden Equipment • Luggage • Military • Office Equipment & Furniture • Power Mowers • Photo & Safety Equipment • Sporting Goods • Toys • Telephones • Radio & Television

Little League Helmets

Football Pads

Refrigerator Trailer Liners

Refrigerator Car Liners



TYPICAL PROPERTIES OF

GRADE AND CHARACTERISTICS	TEST METHOD ASTM	H MAXIMUM TOUGHNESS	L MAXIMUM TOUGHNESS AT LOW TEMPERATURE	T TOUGHNESS WITH MAXIMUM FLOW
PROPERTIES				
Tensile Strength[2], psi 160°F 73°F −40°F	D638-60T	2,900 5,100 7,800	2,900 5,100 7,800	3,800 6,400 9,400
Tensile Modulus,[2] psi 73°F	D638-60T	220,000	220,000	300,000
Flexural Strength[1], 160°F, 73°F, −40°F	D790-59T	No failure	No failure	No failure
Flexural Yield Strength[1], psi 160°F ⅛″x1″x4″ bar 73°F −40°F	D790-59T	4,400 7,500 11,800	4,600 7,800 11,800	5,900 10,000 15,000
Flexural Modulus[1], psi 160°F ⅛″x1″x4″ bar 73°F −40°F	D790-59T	190,000 240,000 260,000	190,000 240,000 260,000	240,000 310,000 360,000
Rockwell Hardness[1]	D785-60T	R87	R86	R101 M10
Specific Gravity[1]		1.02	1.02	1.04
Wear Index, Taber Volume Loss Method CS-17 wheel, 1000g weight 73°F, 50% R.H.		22.7	23.0	18.8
Water Absorption[2], % increase 24 hours, 73°F	D570-59T	0.2-0.3	0.2-0.3	0.2-0.3
Izod Impact Strength ft. lb./inch notch Unnotched 73°F Notched 73°F −20°F −40°F	D256-56 Method A	⅛″ bar[2] 34.0 5-7 2.0 1.5	⅛″ bar[2] 38.0 6-8 3.0 2.5	⅛″ bar[2] 30.0 3-5 1.4 1.0
Charpy Impact Strength[1] ft. lb./inch notch Unnotched 73°F Notched 73°F −20°F −40°F	D256-56 Method B	¼″ bar[1] >40.0 4.9 2.3 2.0	¼″ bar[1] >40.0 6.2 3.2 2.7	¼″ bar[1] 26.5 3.4 1.6 1.5
Deflection Temperature[1], °F, 264 psi ½″x½″x5″ bar 66 psi (unannealed) zero load	D648-56	196 208 220	196 208 223	192 208 220
Deflection Temperature[1], °F, 264 psi ½″x½″x5″ bar 66 psi (annealed) zero load		220 225 231	224 230 241	211 221 226
Coefficient of Linear Thermal Expansion[1], in/in/°C	D696-44	10.4×10^{-5}	10.1×10^{-5}	8.9×10^{-5}
Thermal Conductivity[1] Btu/hr./ft.[2]/°F in. Cal/sec./cm[2]/°C/cm	C177-45	1.46 5.05×10^{-4}	1.46 5.05×10^{-4}	1.54 5.30×10^{-4}
Flammability[1], in/min ⅛″ thick bar	D635-56T	1-1.5	1-1.5	1-1.5
Deformation under load[1], % 24 hr./122°F/2000 psi	D621-59	1.38	1.35	0.81
Mold Shrinkage[2], %	D955-51	0.5	0.5	0.5
Dielectric Constant[1] 60 cycles 10^3 cycles 10^6 cycles	D150-59T	2.87 2.86 2.76	2.86 2.85 2.77	2.91 2.91 2.44
Power Factor[1] 60 cycles 10^3 cycles 10^6 cycles	D150-59T	.005 .006 .009	.005 .006 .008	.005 .006 .008
Volume Resistivity[1], ohm-cm	D257-58	$>3.80 \times 10^{16}$	$>3.92 \times 10^{16}$	$>3.96 \times 10^{16}$
Arc Resistance[1], Sec	D495-58T	71	71	82
General Chemical Properties	D543-56T			
The results given are based upon tests which we believe to be reliable. Due to variance of materials, conditions, and methods of processing, we cannot guarantee results to be obtained. Nothing contained in this brochure is intended as a recommendation to use our products so as to infringe on any patents.	[1]Compression Molded [2]Injection Molded [3]Shore D	INJECTION MOLDING SHEET EXTRUSION	SHEET EXTRUSION	INJECTION MOLDING

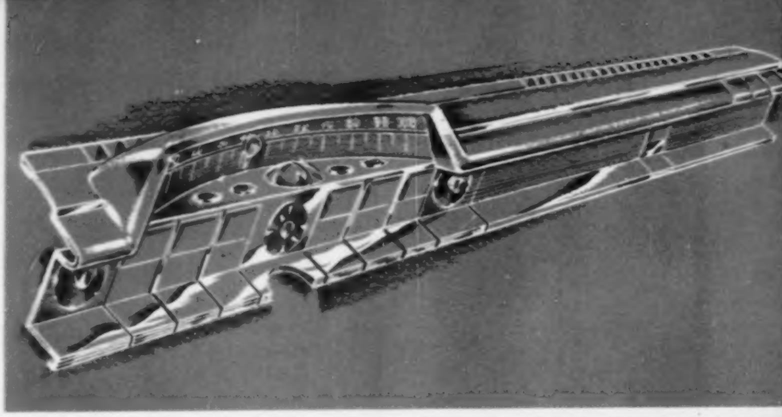
CYCOLAC® BRAND POLYMERS

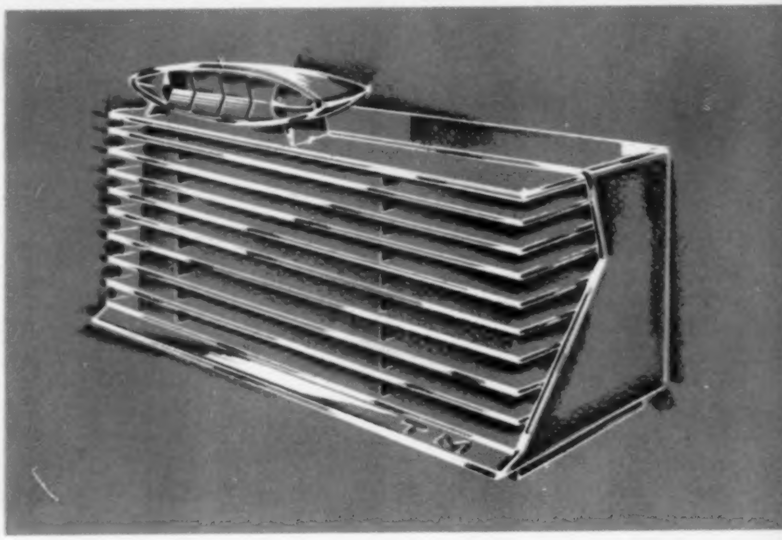
GS	X7	SF	B	LL	C
			ABS TYPE I	ABS TYPE IA	ABS TYPE II
MAXIMUM TOUGHNESS HIGH MODULUS	HIGH HEAT	SEMI-FLEXIBLE EXTRUDED PROFILE	PIPE RESINS AVAILABLE IN BLACK ONLY		
3,500	4,700		2,900	2,900	4,600
6,500	7,100	2,400[1]	5,100	5,100	7,800
10,000	10,400		7,800	7,800	11,500
290,000	330,000		210,000	230,000	350,000
No failure	No failure	No failure	No failure	No failure	No failure
5,900	6,800	1,900	5,100	5,100	6,900
9,400	10,700	4,100	8,000	8,000	10,800
13,100	16,300	7,100	11,800	11,800	18,500
210,000	270,000	60,000	190,000	190,000	310,000
290,000	340,000	120,000	240,000	240,000	370,000
330,000	380,000	150,000	260,000	260,000	420,000
R100	R105	63*	R88	R86	R108
	M29				M35
1.04	1.05	0.99	1.04	1.04	1.06
19.2	19.0		25.5	25.5	22.8
0.2-0.3	0.2-0.3		0.2-0.3	0.2-0.3	0.2-0.3
⅛" bar[2]	⅛" bar[2]	¼" bar[1]	⅛" bar[1]	⅛" bar[1]	⅛" bar[2]
	24.0		>40.0	>40.0	29.0
5-8	3-5	2.2	7.0	7.5-9.5	4-5
2.3-2.6	1.6		3.0	4.5	0.9
2.1-2.3	1.0		2.0	2.5	0.7
¼" bar[1]	¼" bar[1]	¼" bar[1]	¼" bar[1]	¼" bar[1]	¼" bar[1]
>40.0	40.0	>40.0	>40.0	>40.0	>40.0
5-8	2.5	2.0	6.1	7.5	3.4
2.5-3.0	2.0		3.0	4.0	1.3
2.3-2.5	1.3		2.7	3.2	1.0
192	208	144	196	196	215
208	225		208	208	227
222	234		223	223	238
211	229		224	224	232
221	235		230	230	236
226	241		241	241	244
9.35×10^{-5}				10.1×10^{-5}	7.8×10^{-5}
1.55				1.35	1.80
5.45×10^{-4}				4.64×10^{-4}	6.20×10^{-4}
1-1.5	1-1.5		1-1.5	1-1.5	1-1.5
GSE 0.98					
GSM 1.18					
GSS 1.46				1.60	0.41
0.5	0.3			0.5	0.5
2.84				3.20	3.24
2.81				3.12	3.21
2.76				2.90	3.11
.007				.005	.005
.007				.007	.006
.010				.014	.012
$>4.10 \times 10^{16}$				$>3.54 \times 10^{16}$	$>3.57 \times 10^{16}$
E 77				50	87
M and S 47					

Marbon resins are almost completely resistant to aqueous acids, alkalies and salts. Concentrated sulfuric and nitric acids produce disintegration but concentrated phosphoric and hydrochloric acids have little effect. Low KB solvents, alcohols, and animal, vegetable and mineral oils produce insignificant changes.

Glacial acetic acid, carbon tetrachloride, aromatic hydrocarbons and high KB solvents cause marked swelling. Esters, ketones, and ethylene dichloride are solvents.

GS	X7	SF	B / LL / C
GSE – SHEET EXTRUSION GSM – INJECTION MOLDING GSS – SHAPE EXTRUSION	INJECTION MOLDING	SHAPE EXTRUSION	EXTRUSION





CYCOLAC ® BRAND POLYMERS

offers new materials for the creative engineering of tomorrow's products ...TODAY!

Performance-proved in the products of today, CYCOLAC brand plastic is ready to meet the challenge of tomorrow. Because it can be fabricated by a variety of techniques and because it offers such a wide range of properties, this versatile Borg-Warner material is already helping new products on the drawing board become feasible production items. Its true potential is limited only by the imagination of industry's designers and engineers. Think of the thousand and one ways, CYCOLAC brand polymers can go to work for you, today!

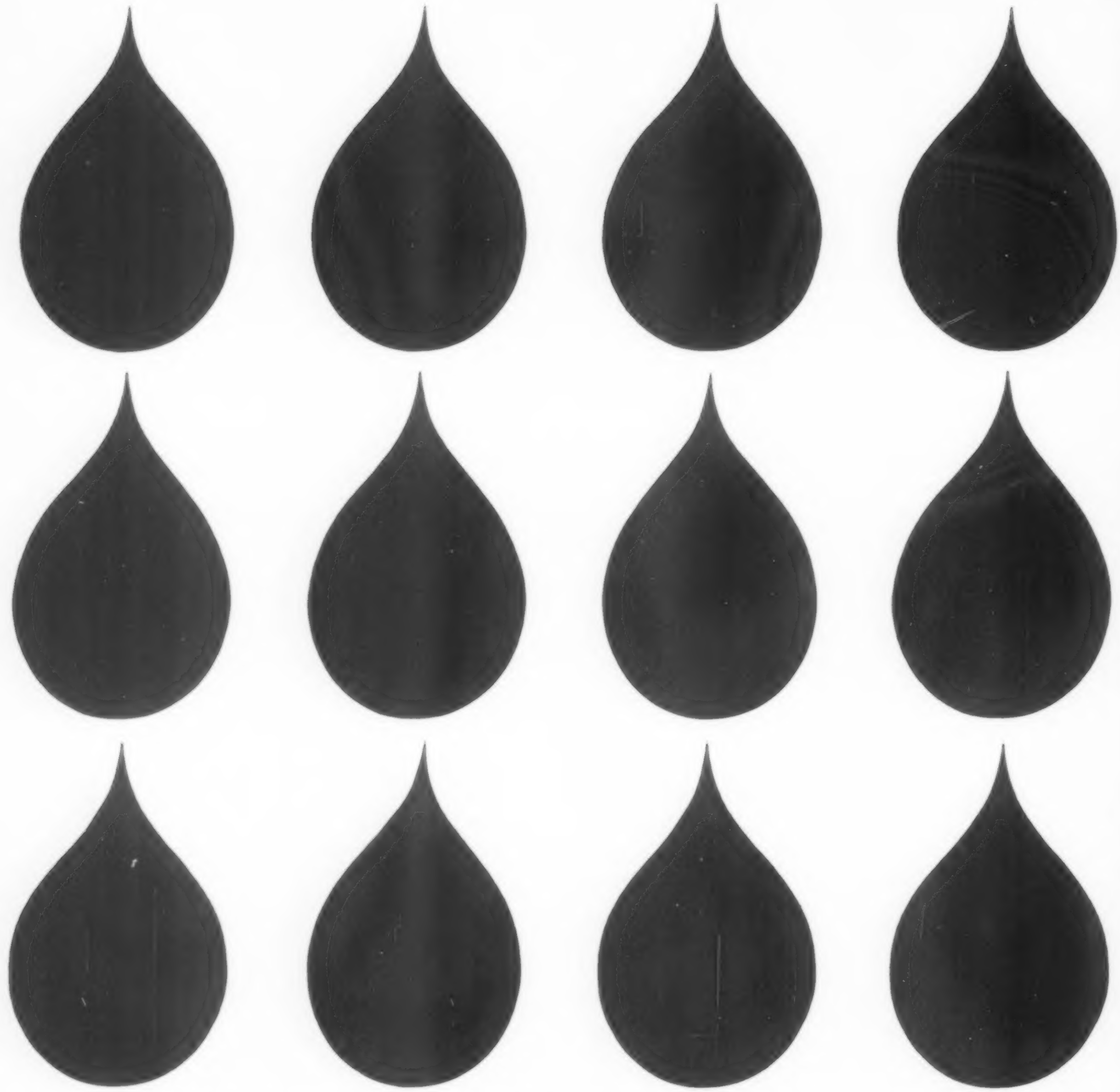
MARBON CHEMICAL DIVISION **BORG-WARNER**
WASHINGTON WEST VIRGINIA

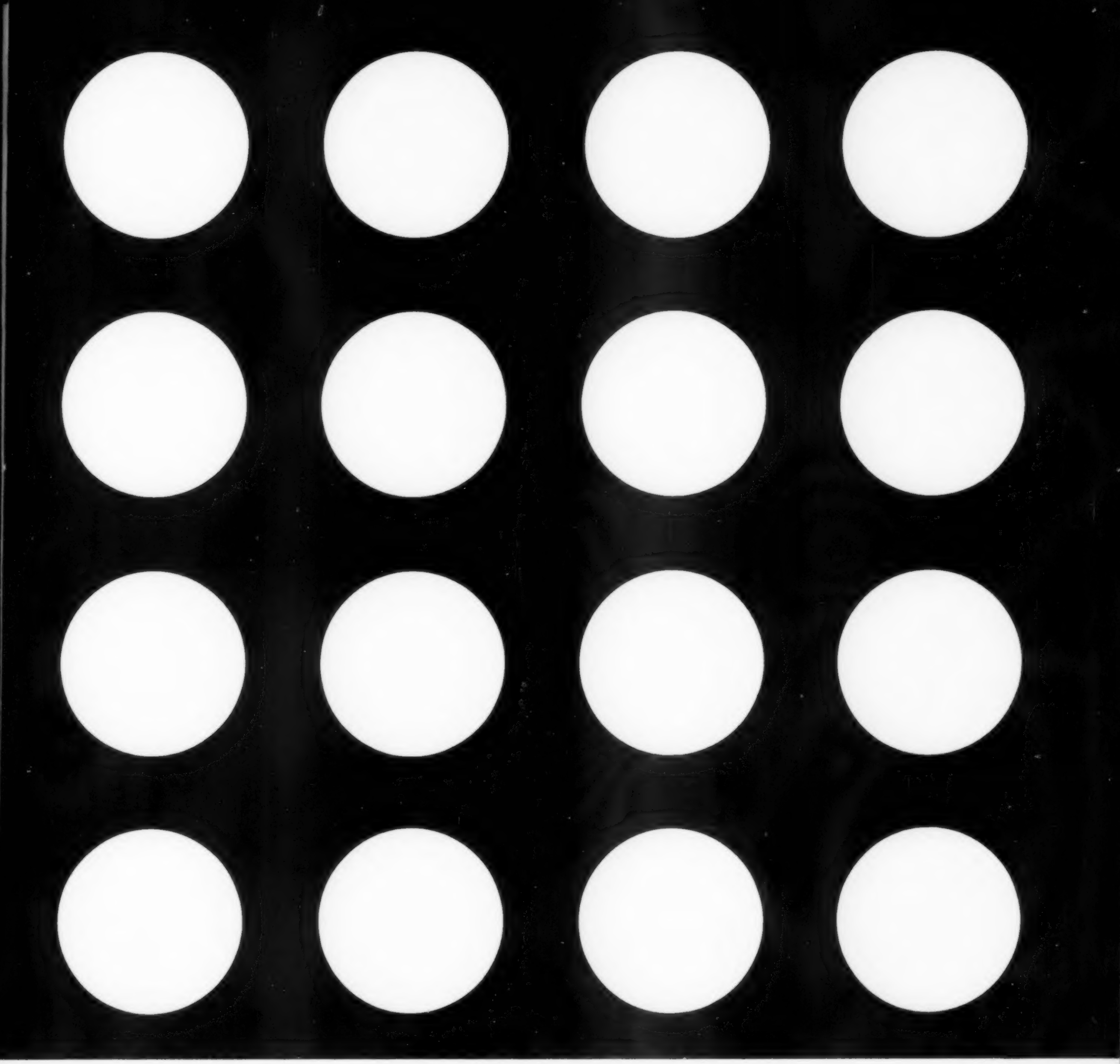
MARBON B-W CHEMICAL

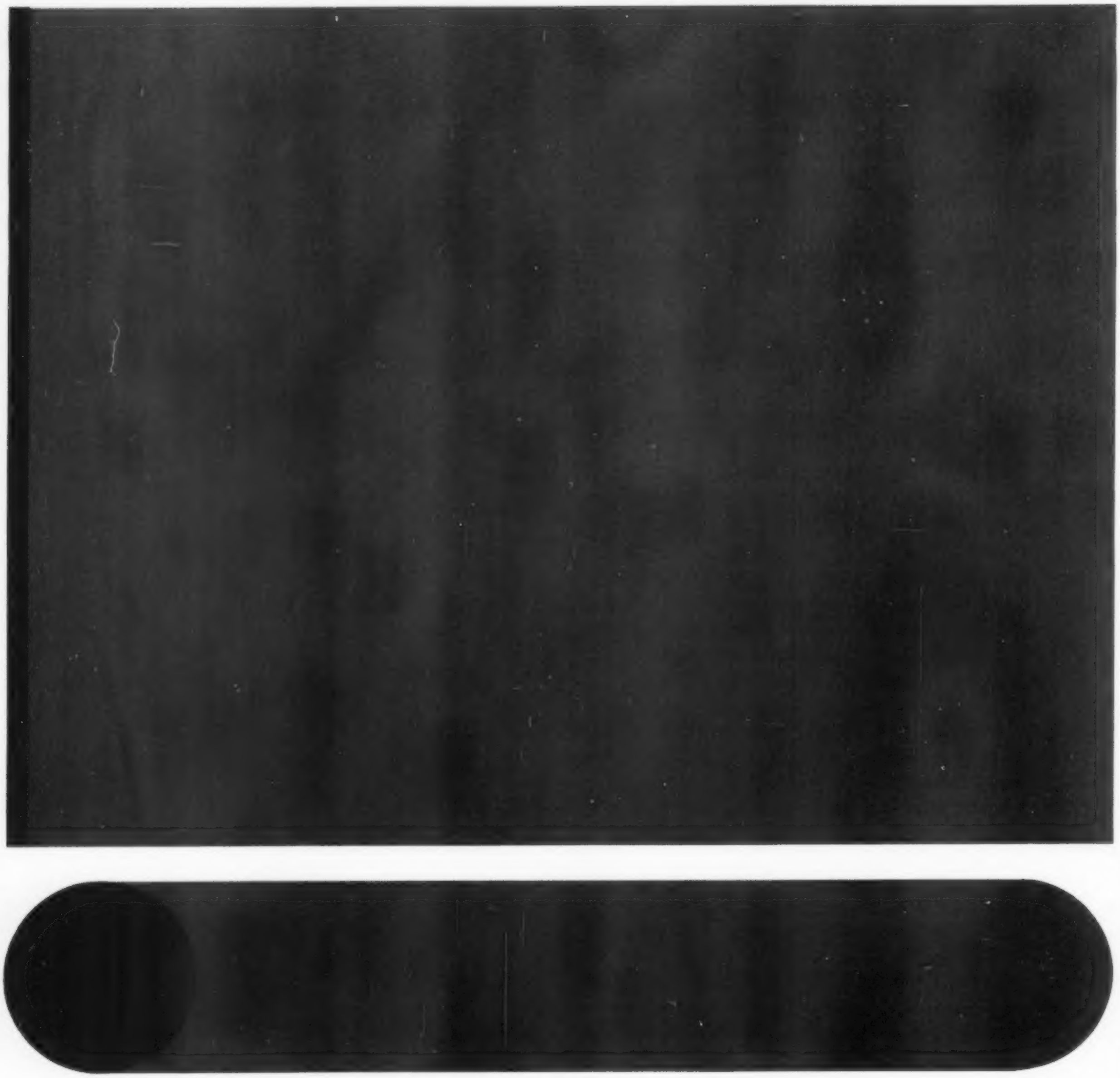
Form 10240-561

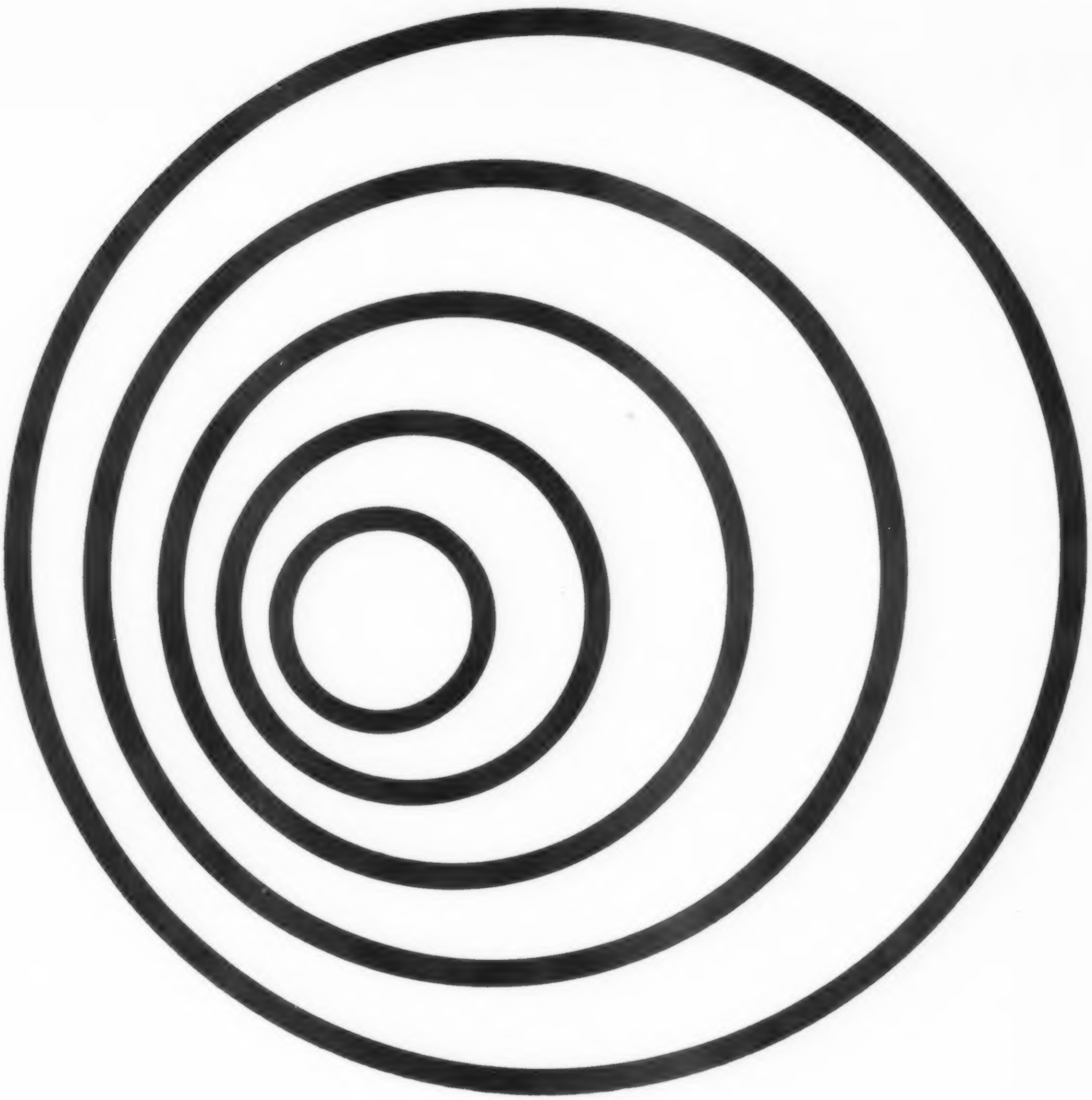
PRINTED IN U.S.A.

NEW ADVANCED LAMINATES FROM WESTINGHOUSE MICARTA









WESTINGHOUSE MICARTA SELECTOR TABLE

MICARTA GRADES		NEMA	BASE MATERIAL	MILITARY SPECIFICATION TYPE AND NUMBER □
TAN	BLACK			
paper base grades				
213	423	X	kraft paper	
219	429	XX	absorbent paper	MIL-P-3115-B-PBG
254	464	XXX	absorbent paper	MIL-P-3115-B-PBE
H-10664		XXP	absorbent paper	
20618-2	20618-1	X	paper	
H-5640		XXXPC	paper	MIL-P-3115-B-PBE-P
	20400		paper	
H-9454		FR-3	paper	MIL-P-22324-PEE
H-12980		XP	paper	
cloth base grades				
262	466	C	coarse weave fabric	MIL-P-15035-B-FBM
286	496	CE	medium weave fabric	MIL-P-15035-B-FBG
238	448	L	fine weave fabric	MIL-P-15035-B-FBI
221	431	LE	fine weave fabric	MIL-P-15035-B-FBE
400			medium weave fabric	
223			coarse weave fabric	MIL-P-18324-A
273			fine weave fabric	
281			medium weave fabric	
20601		CM	medium weave fabric	
glass base grades				
259-2		G-5	fiberglass cloth	MIL-P-15037-B-GMG
20201		G-7	fiberglass cloth	MIL-P-997-B-GSG
20202		G-6	fiberglass cloth	MIL-P-997-B-GSG
H-5834		G-3	glass fabric	MIL-P-25515
H-9758			fiberglass cloth	
H-2497		G-11	glass cloth	MIL-P-18177-B-GEB
H-8457		G-10	glass cloth	MIL-P-18177-B-GEE
others				
200		AA	asbestos fabric	
239		A	asbestos paper	
293			asbestos fabric-melamine resin	
20209		N-1	nylon	MIL-P-15047-B-NPG

□ Specifications apply to tan grades only

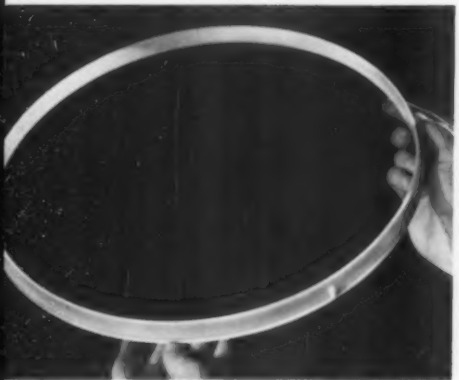
F 29 POPULAR GRADES

CHARACTERISTICS
high tensile, flexural and compressive strength; fair electrical strength; not for machining or high humidity applications
good electrical properties in dry and humid conditions; fair mechanical strength; good for machining operations
high humidity resistance; good dimensional stability best resistance to splitting of paper grades
superior insulation resistance; excellent warm punching
economy punch plate; cold punch below 1/16″
electrical punch grade
refinishing black
paper epoxy; flame retardant; punchable; better electrical properties than standard XXXP
good electrical and moisture resisting qualities; excellent warm punching characteristic
good mechanical properties; especially high impact strength
low voltage; low frequency electrical performance; lower impact strength than grade 262
high mechanical strength; appearance; strength in punching
machining qualities; mechanical and electrical strength; moisture resistance; toughness; good appearance; low power factor
low coefficiency of friction; self lubricating (graphite filled)
low moisture absorption; toughness; good dimensional stability; marine bearing grade
high moisture, acid and alkali resistance; good dimensional stability and compressive strength
low moisture absorption; good dimensional stability; resists acid, alkalis
good arc and alkali resistance
flame retardant; high mechanical strength; high impact strength
excellent heat and arc resistance; good electrical properties under humid conditions; class H insulation
extremely good dielectric loss and insulating resistance properties under dry conditions; class H; better machinability than G-7 material
high temperature resistance; ablation resistance
economy grade silicone plate; very good for structural members in class H insulation
same as grade H-8457 except guaranteed to maintain more than 50% initial flexural strength under E-1/150, T-150; flame retardant
high voltage insulation; class B insulation; glass cloth epoxy resin; better macninability than G-11 material
heat resistance (125°C) and mechanical strength; high impact strength
heat resistance (125°C), mechanical and electrical strength; fair impact strength
good heat and transformer insulation
high electrical properties under humid conditions; high impact strength

working with

Du Pont Delrin®

one of Du Pont's versatile engineering materials



This molded ring of DELRIN is key unit of a simplified bearing system for the revolving drum of an RCA Whirlpool dryer. The bearing design requirements, which led directly to DELRIN, included excellent frictional properties, abrasion resistance, dimensional stability and retention of physical properties in a moist atmosphere at temperatures up to 200°F., and freedom from warpage. (Molded by Haas Molding Co., Mendon, Michigan, for Whirlpool Corporation, St. Joseph, Michigan.)

DELRIN has replaced an expensive two-piece, spot-welded and copperplated, stamped-steel component in fluorescent light-starter switch. The new one-piece injection-molded part is used as a lock spring. DELRIN acetal resin is a good electrical insulator, has excellent resilience, which gives it the spring-like properties needed here, wear resistance and dimensional stability; costs about half of previous metal component. (Molded by Waterbury Company, Waterbury, Connecticut, for Edwin Gaynor Co., Bridgeport, Connecticut.)

A clamp-on hand brake for cotton spinning spindles uses DELRIN for the handle, the cam and two brake arms. The flexing arms of tough, resilient DELRIN provide automatic adjustment and take-up for wear. DELRIN is easily molded in the complex shapes required, eliminates the need for machining operations. (By Brook Molding Company, Norwood, Mass., for Whitin Machine Works, Whitinsville, Mass.)

Light, tough and resilient DELRIN® simplifies designs . . . cuts costs

Sometimes the simple substitution of a part of DELRIN for a metal part answers a design problem and saves money by eliminating finishing operations and making possible rapid, low-cost injection-molding production. Very frequently, however, the use of DELRIN permits a thorough redesign of a component, with increased operating efficiency, fewer parts, lower assembly costs, lower shipping costs. The resultant cost advantages can be substantial. It will be worth your while to investigate the properties of DELRIN as they apply to your design problems, and to find out more about the many hundreds of production improvements at lower cost that this new material has made possible. Simply mail the coupon below for pertinent information.

POLYCHEMICALS DEPARTMENT

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

E. I. du Pont de Nemours & Co. (Inc.), Dept. 3 A
Room 2507D Nemours Building, Wilmington 98, Delaware
I am interested in evaluating DELRIN for the following use:

____

*Name*______________________________

*Company*____________________ *Position*__________

*Street*______________________________

*City*____________________ *Zone*_____ *State*__________

In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

DELRIN® *acetal resins*

one of Du Pont's versatile engineering materials

Alathon® · Zytel® · Lucite®

YOUR GUIDE TO

DOW

THERMOPLASTICS

STYRON®
POLYETHYLENE
TYRIL®
PELASPAN®
PVC RESINS
SARAN
ZERLON®
ETHOCEL®

AMERICA'S FIRST FAMILY
OF THERMOPLASTICS

DOW

PROVED IN USE FOR:

REFRIGERATOR PARTS
AUTOMOBILE PARTS
WALL TILE
HOUSEWARES
CAMERA COMPONENTS
LIGHTING LOUVERS
RADIO CABINETS
VIALS AND CONTAINERS
PHOTO DEVELOPING TANKS
SCALE MODELS
APPLIANCE HOUSINGS
PACKAGING (RIGID)
CLOSURES
TABLE LEGS

AMERICA'S FIRST FAMILY OF THERMOPLASTICS

STYRON®

POLYSTYRENE. Styron is Dow's trademark for its huge family of polystyrene molding formulations. There's almost no limit to the uses of these versatile materials, covering the full range of products for daily living. General purpose Styron materials combine economy with improved molding and extrusion properties. Special high impact formulations provide great strength and increased heat resistance. Styron also offers low moisture absorption, high dimensional stability, wide range of colors. Styron Verelite is light stabilized. Styron can be extruded, vacuum formed, calendered, and injection molded.

GENERAL PURPOSE:

STYRON 666–Widely used for molding and extrusion. Excellent balance of physical properties.

STYRON 666M–Similar to 666, with improved flow characteristics.

STYRON 678–Easy flow with improved heat resistance results in faster cycles.

STYRON 689–Highest flow characteristics, for general purpose molding.

HEAT RESISTANT:

STYRON 683–General purpose type, good heat resistance.

STYRON 700–Highest heat resistant polystyrene.

STYRON 690–Improved toughness, good heat resistance.

IMPACT GRADES:

STYRON 315–Medium impact with ease of fill and good set up characteristics.

STYRON 330–Medium impact, improved flow and translucency.

STYRON 345–Medium impact with improved toughness.

STYRON 475–High impact, with 3 to 5 times greater impact strength and 9 times greater elongation than general purpose formulations.

STYRON 475M–Easy flow, high impact.

STYRON 475B–Extra high impact.

STYRON 475C–Extra high impact, easy flow.

STYRON 480–Extreme impact strength, good heat resistance.

HIGH IMPACT, HEAT RESISTANT:

STYRON 369–Medium impact, high heat resistance.

STYRON 440–High impact, high heat resistance.

STYRON 440M–Styron 440 type with improved flow.

LIGHT STABILIZED:

STYRON 672 VERELITE®–General purpose, light stablized for molding.

STYRON 673 VERELITE–General purpose, light stabilized for extrusion.

DOW

PROVED IN USE FOR:

BOTTLES
WIRE COVERING
CABLE COVERING
PACKAGING FILM
CLOSURES
HOUSEWARES
TOYS
PIPE
INDUSTRIAL PARTS AND COMPONENTS
FOOD PACKAGING MATERIALS
FITMENTS AND LIDS
CONSTRUCTION—AG FILM
INDUSTRIAL PACKAGING
TABLE CLOTHS AND DRAPERIES
FILMS

AMERICA'S FIRST FAMILY OF THERMOPLASTICS

POLYETHYLENE

Almost unlimited property combinations are possible with Dow's complete line of polyethylene—in low, medium, and high densities. Dow provides the industry's most complete line of molding and extrusion formulations. Dow polyethylene is tough and flexible over a range of temperatures from below −25° to above 210° F. Toughness, clarity and moisture barrier characteristics make it ideal for film applications. Other outstanding properties are: high finish, crack resistance, and superior impact resistance.

INJECTION MOLDING:

POLYETHYLENE 410M, 610M, 700M, 900M, 901M, 910M—Low density, flexibility.

770M, 771M, 990M, 991M, 1000M, 1001M—Intermediate density, gloss and rigidity.

R600, R800—High density, maximum rigidity.

R810—High density copolymer, stress resistance.

ZETAFIN* 70—Low density copolymer, maximum flexibility.

EXTRUSION:

POLYETHYLENE 510E, 514E, 515E— Low density impact film.

544E, 545E, 546E, 641E, 642E, 643E, 644E—Low density, high clarity and gloss packaging film.

550E, 551E—Intermediate density, specialty film.

561E, 562E, 563E, 564E—Low density general purpose film from produce to textile packaging.

571E, 572E, 573E—Low density high clarity, gloss and impact blown film.

662E, 663E—Intermediate density overwrap film.

775E—Intermediate density garment bag film.

ZETAFIN 35—Copolymer, extremely flexible specialty film.

PC-52, PC-55, PC-60—Pipe extrusion.

103A1, 107A3, 303A1, 305A3, 305A4— Electrical grades for wire and cable covering extrusion.

BLOW MOLDING:

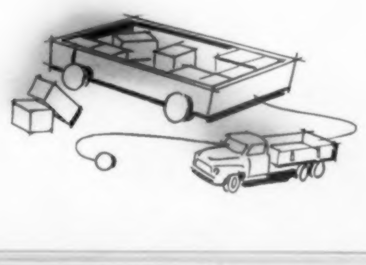
POLYETHYLENE 200B, 400B—Low density, flexibility and stress resistance.

R200, R300, R401—High density, maximum rigidity.

R210, R211—High density copolymer, maximum stress resistance.

ZETAFIN 30 – Low density copolymer, maximum flexibility and stress resistance.

*Trademark



DOW

PROVED IN USE FOR:

AUTOMOBILE PARTS
APPLIANCE COMPONENTS
NOZZLES
TUMBLERS
CLOSURES
MEDICAL EQUIPMENT COMPONENTS
BRUSH BLOCKS
BATTERIES
TELEPHONE COMPONENTS
FILM
FOOD CONTAINERS
BRISTLES AND FILTERS
MONOFILAMENTS

AMERICA'S FIRST FAMILY OF THERMOPLASTICS

TYRIL®

A COPOLYMER OF STYRENE ACRYLONITRILE. Tyril is a rigid thermoplastic material with exceptionally high strength and toughness. High critical elongation means high resistance to crazing, and long service life for molded parts. Close fitting working parts benefit from high dimensional stability, too. Where resistance to acids, bases, salts, oils, waxes, soaps, food stains and solvents is important, Tyril serves well. And Tyril is easily molded or extruded. Three formulations of Tyril are available to meet the requirements of specific applications.

STRENGTH—Tyril has a tensile strength (⅛" test bar) as high as 11,000 psi and elongation values to 3.7%. The stress required to crack or craze Tyril in air is two to three times that of general purpose polystyrene.

FOOD SAFETY—Tyril has been accepted for food contact by the Food and Drug Administration, and by the Meat Inspection Division, Agricultural Research Service, U.S.D.A.

THERMAL STABILITY—Stability of Tyril to fabrication temperatures is good, if recommended procedures are followed.

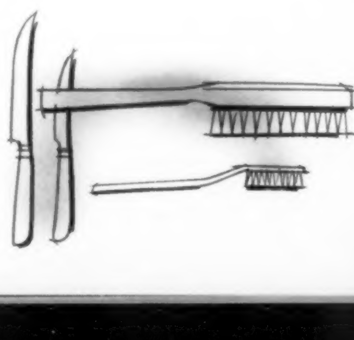
EXTRUSION—Tyril can be extruded in any shape normally possible with rigid thermoplastic materials. However, its characteristics and properties adapt it especially well for bristles and other monofilament applications.

INJECTION MOLDING – Tyril can be molded at cylinder temperatures of 400°F. to 550°F. with conventional machines and molds.

TYRIL 750—Intermediate chemical resistance and properties. Easy flow.

TYRIL 767—Good chemical resistance and properties. Intermediate flow.

TYRIL 780 – Excellent chemical resistance and properties. Stiffer flowing.



Dow

PROVED IN USE FOR:

THERMAL INSULATION

BUOYANCY

SANDWICH PANEL CORES

PACKAGING

SHOCK ABSORPTION

TOYS

NOVELTIES

DISPLAYS

LOW DENSITY FILLER

REFRIGERATOR INSULATION COMPONENTS

AMERICA'S FIRST FAMILY OF THERMOPLASTICS

PELASPAN®

EXPANDABLE POLYSTYRENE BEADS. Developed by Dow, Pelaspan is expandable polystyrene in bead form. Pelaspan is processed by prefoaming and subsequent heating in a retaining mold. This results in a smooth surfaced foam that takes the exact shape of the mold, even to intricate contours and convolutions. Almost unlimited shapes and sizes are obtainable. The density of Pelaspan can be varied from 1 to 15 pounds/cu. ft. to provide the precise properties required for insulation, packaging, and other applications.

FORMULATIONS—Pelaspan 8 for regular molding. Pelaspan 18 for molding applications requiring flame retardant material. All formulations in natural color may be tinted, using dry blend or dye coloring.

PELASPAN 101—For regular beadboard block molding and applications requiring internally pigmented granules.

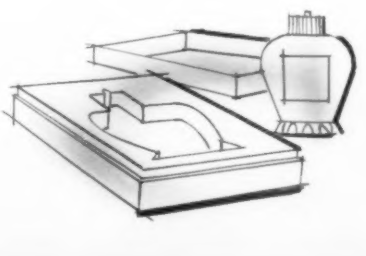
PHYSICAL PROPERTIES—Pelaspan 8, 18 and 101 have: Low thermal conductivity • Low water absorption • Low vapor transmission • High strength-to-weight ratio • Smooth surface • Attractive appearance.

CUSHIONING EFFECT—One of the most useful physical properties of Pelaspan is its ability to cushion without rebound where impact occurs. This makes it uniquely valuable for the packaging, packing and shipping of fragile articles, precision instruments and equipment.

BONDING—Pelaspan can be foamed and bonded simultaneously to metals, other nonporous materials and porous materials using thermally sensitive type adhesives.

INJECTION MOLDING—Frostwood* molded articles are injection molded from Pelaspan beads. They have unique surface characteristics including textured hard surface shells with foamed cores contributing an insulation factor to the article.

*Trademark



DOW

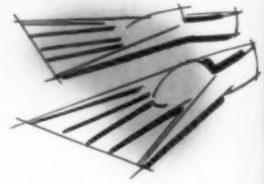
PROVED IN USE FOR:

WIRE COVERING
FILM AND SHEETING
DRAPERIES
SHOWER CURTAINS
GARDEN HOSE
SHOE WELTING
TUBING
GASKETS
CLOSURES
INFLATABLE GOODS

AMERICA'S FIRST FAMILY OF THERMOPLASTICS

PVC RESINS

Available in a complete range of high, medium and low molecular weights, Dow PVC resins have controlled particle size, excellent color and clarity, and remarkable resistance to heat and light. They are furnished as free flowing, unformulated white powders suitable for dry blend processing. Dow PVC resins are suitable for calendering, extruding, and molding.



PVC-100-4, moderately high molecular weight. Has good dry blendability, and excellent physical, aging and electrical properties. UL approved as interchangeable electrical resin.

PVC-144, intermediate molecular weight. Possesses optimum combination of dry blendability, processability, and physical and electrical properties. UL approved as interchangeable electrical resin.

PVC-166, an extra low molecular weight PVC homopolymer resin which retains the physical and heat stability characteristics of homopolymer resins, while approaching the processing characteristics of copolymers. Excellent for rigids.

PVC-111-4, medium molecular weight. For rigid applications, and general purpose use. Wide acceptance in shape and film extrusions, and high speed calendering.

PVC-133-4, medium molecular weight. Easy processing, high plasticizer absorption resin for dry premixes at room temperature, and dry blend extrusions with high plasticizer content.

DOW

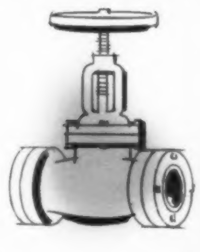
PROVED FOR USE IN:

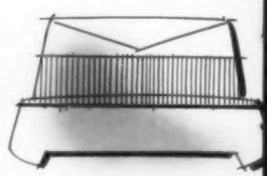
AUTO SEAT COVERS
UPHOLSTERY
DRAPERIES
CARPETING
BRISTLES
PACKAGING FILM
FITTINGS AND COUPLINGS
PIPE AND PIPE LINING
ACID RESISTANT FILTER CLOTHS
AWNINGS
DOLL HAIR

AMERICA'S FIRST FAMILY OF THERMOPLASTICS

SARAN

POLYVINYLIDENE CHLORIDE RESINS. Saran resins are among the most inert of all thermoplastics. They offer outstanding combinations of properties: toughness, flexibility, durability, abrasion resistance, extreme chemical resistance. They are colorless, odorless, self-extinguishing and have extremely low water absorption and vapor transmission rates. Primary processing methods are molding and extrusion.





SARAN 115E, 820, 843, 732—For extruding as monofilaments, for woven products.

SARAN 862, 909, 723, 422, 746—For extrusion as multifilaments and fine fibers.

SARAN 864—For extruded tubing and sheeting.

SARAN 281—Molding, for pipe fittings, other industrial products.

PROVED FOR USE IN:

AUTOMOBILE COMPONENTS

APPLIANCE PARTS

DISPLAYS

OUTDOOR SIGNS

SPECIALTY ITEMS

NOVELTIES

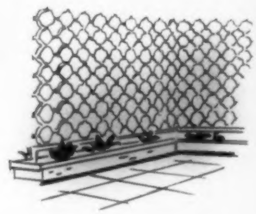
DECORATIVE PRODUCTS

BOAT WINDSHIELDS

AMERICA'S FIRST FAMILY OF THERMOPLASTICS

ZERLON®

COPOLYMER OF METHYL METHACRYLATE STYRENE Zerlon is the newest of Dow's thermoplastics. This unique methyl methacrylate styrene copolymer offers an outstanding combination of properties: optical clarity, resistance to weathering, high tensile strength, high elongation, toughness, and resistance to heat. Zerlon is economical because of low material cost, and ease of fabrication. A single formulation, Zerlon 150, is suitable for both injection molding and extrusion.



MOLDING—Zerlon 150 can be molded with conventional equipment. Because it is not compatible with other thermoplastic materials, cylinders should be purged before molding.

EXTRUSION—Zerlon 150 can readily be extruded into many shapes, and sheeting. Conventional extruders with length-to-diameter ratios of 18:1 or greater are preferred.

PROVED IN USE FOR:

FOOTBALL HELMETS

SAFETY HEADGEAR

TOOTHBRUSH HANDLES

LUGGAGE

APPLIANCE PARTS

TABLE EDGINGS

VACUUM FORMING

CIGAR HOLDERS

CHAIR ARM RESTS

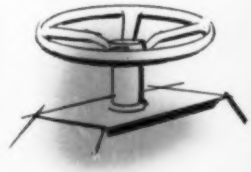
MILITARY USES

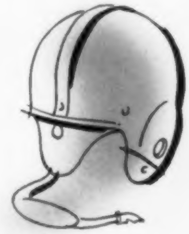
AMERICA'S FIRST FAMILY OF THERMOPLASTICS

ETHOCEL®

DOW ETHYLCELLULOSE. Ethocel molding compounds provide a maximum of toughness, dimensional stability, chemical resistance and high impact strength. Its excellent moldability makes large, single-unit moldings practical. Ethocel is available in a full range of transparent, translucent and opaque colors, with a high lustre.

For coatings applications, Ethocel offers an unusual combination of properties—heat stability, low temperature flexibility, compatibility with waxes and low cost plasticizers.





ETHOCEL 860—General purpose for molding and extrusion.

ETHOCEL 855—Extremely rigid, good low-temperature impact resistance, high gloss.

ETHOCEL 856—Less rigid than 855. Excellent dimensional stability.

ETHOCEL 870—Good impact resistance, high heat resistance.

ETHOCEL 880—Extreme impact resistance at low temperatures.

ETHOCEL 890—Extreme heat resistance, high impact resistance.


Allied
Chemical

Allied Chemical – Plastics Division

PLASKON ALKYD AND ALKYD (DAP) MOLDING COMPOUNDS

Granular Type

Granular materials are designed for high-speed, fully automatic or semi-automatic molding operations. They include glass and mineral-filled grades. Contacts may be molded in or inserted in a separate procedure.

PROPERTIES
Provide high arc and insulation resistance and dielectric values which are maintained at elevated temperatures and after exposure to heat and humidity. Molded parts have unusually high dimensional stability (minimum after-shrinkage). This, plus the fact they are generally adaptable to rapid production cycles, permits endless reproduction of precision parts.

There are PLASKON Alkyd granular types that conform to the MIL-M-14F specification, Type MAG and, the poly diallyl phthalate type, MDG.

APPLICATIONS
Tube bases and sockets, connectors, tuning devices, transformer parts, potentiometer parts, motor controller parts, auto ignition parts, switch and relay parts.

Putty Type

For encapsulation of small electronic parts where delicate inserts are to be sealed within a protective shell. Molds rapidly at extremely low pressures. Available in soft, putty-like sheets. Easy to handle — no mixing required.

PROPERTIES
For many applications the coefficient of linear thermal expansion will be found similar to popular wire types (their thermal conductivity dissipates heat faster) producing less change in dielectric performance before and after encapsulation. Conform to the MIL-M-14F specification, Type MAG.

APPLICATIONS
Resistors, capacitors, coils, transformers, small electronic devices.

Impact Types

Reinforced with glass fiber for increased impact strength. Combines the electrical qualities typical of Alkyds with the high strength of glass fiber reinforcement. Also retains excellent dimensional stability characteristics of all Alkyd Molding Compound types. Suitable for compression and transfer molding.

Grades available to conform with the MIL-M-14F specification, Type MAI-30 and MAI-60; and MIL-M-19833, Type GDI-30.

APPLICATIONS
Computer parts, synchros, coil forms, terminal blocks, connectors, stand-off insulators, heavy-duty circuit breakers and switch gear.

PLASKON COATING RESINS

A complete line of alkyd, urea, melamine, styrenated alkyd, silicone alkyd, modified phenolic, maleic and ester gum resins for the surface coating and printing industries.

PROPERTIES
Each resin is designed to deliver specific performance characteristics such as gloss, superior gloss retention, chemical and solvent resistance, durability and rapid drying.

APPLICATIONS
Paints, varnishes, lacquers, printing inks and self-polishing floor waxes. Exterior and interior appliance, automotive and industrial uses.

PLASKON PHENOLIC RESINS

A family of outstanding thermosets. Properly applied, they result in strong, rigid, dimensionally stable products. A new pre-mix resin permits preparation of reinforced molding materials using the economical pre-mix method.

PROPERTIES
Unaffected by water, alcohol, oils, greases, mild acids and common solvents. Excellent heat resistance up to 700°F. when laminated with glass cloth. No marked change at freezing temperatures. Excellent electrical properties. Special grades offer extreme chemical resistance.

APPLICATIONS
Plaskon Phenolic Laminating Varnishes are widely used in decorative and electrical-grade laminates. New flame-retardant resins are available for switchgear and printed circuits. A special resin has been developed for aircraft and missile parts. Other uses include thermal insulation, battery separators, oil and air filters, shell molds and foundry cores.

PLASKON POLYESTER RESINS	PLASKON HALON* RESINS TYPES VK & TVS	PLASKON MELAMINE	PLASKON NYLON-6	PLASKON UREA

PLASKON POLYESTER RESINS

A line of specially formulated resins for cost-saving pre-mix molding, which permit rapid production of parts of varying thicknesses, intricate contours or molded-in inserts. Molders can use their own reinforcements, fillers and catalysts.

PROPERTIES
Great strength and light weight in reinforced plastic laminates. "Built-in" molding advantages include pre-acceleration to speed production, rapid impregnation and excellent release for matched-metal molding. Plaskon Polyesters for matched-metal molding offer better mold release, higher gloss and less crazing than general-purpose resins.

APPLICATIONS
Boats, housings, translucent panels, furniture, packaging and aircraft components.

PLASKON HALON* RESINS TYPES VK & TVS

Fluorohalocarbon plastics for difficult design problems. Easily extruded, compression and injection molded. Structure retards crystallization during slow cooling cycles after exposure to high temperatures—tending to maintain toughness, flexibility and clarity.

PROPERTIES
Built-in flexibility, radiation resistance and excellent moldability. Virtually unaffected by inorganic acids, alkalies or oxidizing agents. No moisture absorption. Easy to clean. Excellent optical qualities. Transparent up to ⅛-inch cross section. Resistant to heat and cold: Type VK serviceable up to 350°F., TVS to 390°F. Thin sections can be flexed at −320°F. Good abrasion resistance, impact tensile and compressive strength. High volume and surface resistivity at high and low temperatures. Low dielectric constant and good power factor at high temperatures and frequencies. Nonflammable.

APPLICATIONS
Insulation for hook-up wire, printed circuit boards, flexible cable and cable assemblies. Coil forms, tube sockets, terminal insulators, etc. Lining material for storage tanks, pipe lining, gaskets, "O" rings, etc. Caps for containers of highly corrosive liquids.

PLASKON MELAMINE

A molding compound which provides the hardest surfaces attainable with plastics.

PROPERTIES
Excellent arc resistance, hardness, lightfastness. Inert to chemical and pharmaceutical reagents. Highly resistant to electrical tracking. Tasteless and odorless. Surpasses urea in resistance to acids, alkalies, heat and moisture absorption. Varying degrees of translucency permit unlimited color range.

APPLICATIONS
Dinnerware, appliance housings, electrical parts and wiring devices, cutlery handles and buttons.

PLASKON NYLON-6

New types of molding and extrusion compounds different from previously available domestic nylon. A polymer of caprolactam.

PROPERTIES
Unusual toughness, abrasion resistance, self-lubrication, high heat-distortion temperature, high strength-to-weight ratio and good chemical resistance. Less shrinkage and superior dimensional control than other nylon types. Broader melting range—can be molded at lower temperatures and pressures. Superior impact strength, better moldability in thick sections, easier pigmentation.

APPLICATIONS
Precision parts such as gears, cams and bearings. Small tubing, shapes, small and large rod, film, laminates, wire and rope covering. Parts requiring stability against oxidative embrittlement at high temperatures. Fish line, heel lifts, pipe fittings, pipe, blown bottles.

PLASKON UREA

A molding compound that comes in an extremely wide range of colors — pure white, pastels and brilliant hues. A special housing type has been developed for large parts fabrication.

PROPERTIES
Tasteless, odorless and inert. Resistant to grease, oil, solvents, heat, chipping and cracking. High dielectric strength and arc resistance. Excellent dimensional stability.

APPLICATIONS
Closures, wiring devices, stove and cabinet hardware, toilet seats, lighting fixtures, radio, appliance and other housings, cosmetic and jewelry containers, buttons.

*Trade Mark

Allied Chemical

BASIC TO AMERICA'S PROGRESS

Allied Chemical — Plastics Division

PLASKON FIRE-RESISTANT UREA UFR-28	PLASKON WOOD-FLOUR FILLED UREA	A-C® POLYETHYLENE 6

PLASKON FIRE-RESISTANT UREA UFR-28

A molding compound with low flame-spread rating, supplied in unpigmented natural color and a range of tint shades.

PROPERTIES

Self-supporting rigidity. UL flame-spread rating of 25 to 75. Meets fire-resistance requirements of municipal, state and national building codes.

APPLICATIONS

Lighting and appliances. Ideal for luminescent ceilings.

PLASKON WOOD-FLOUR FILLED UREA

An improved general-purpose molding compound available in black, NEMA closure browns and large-volume special opaque colors.

PROPERTIES

Tasteless and odorless. Highly resistant to electrical tracking; excellent arc resistance and insulation properties. Hard; lightfast; inert to chemical and pharmaceutical reagents. Often performs as well as cellulose-filled urea, differing mainly in opacity and color quality.

APPLICATIONS

Wiring devices, switch plates, closures, household circuit breakers and light industrial switch gear.

A-C® POLYETHYLENE 6

A processing aid and modifier for use in injection molding, slush molding and extrusion. By varying the amount of A-C Polyethylene 6, you can tailor the resin melt index to meet any molding problem.

PROPERTIES

Tasteless, non-discoloring. Unusually inert and very stable. Resistant to water, dilute acid solutions, and basic solutions such as ammonium hydroxide and sodium hydroxide. Compatible with most hydrocarbon polymers.

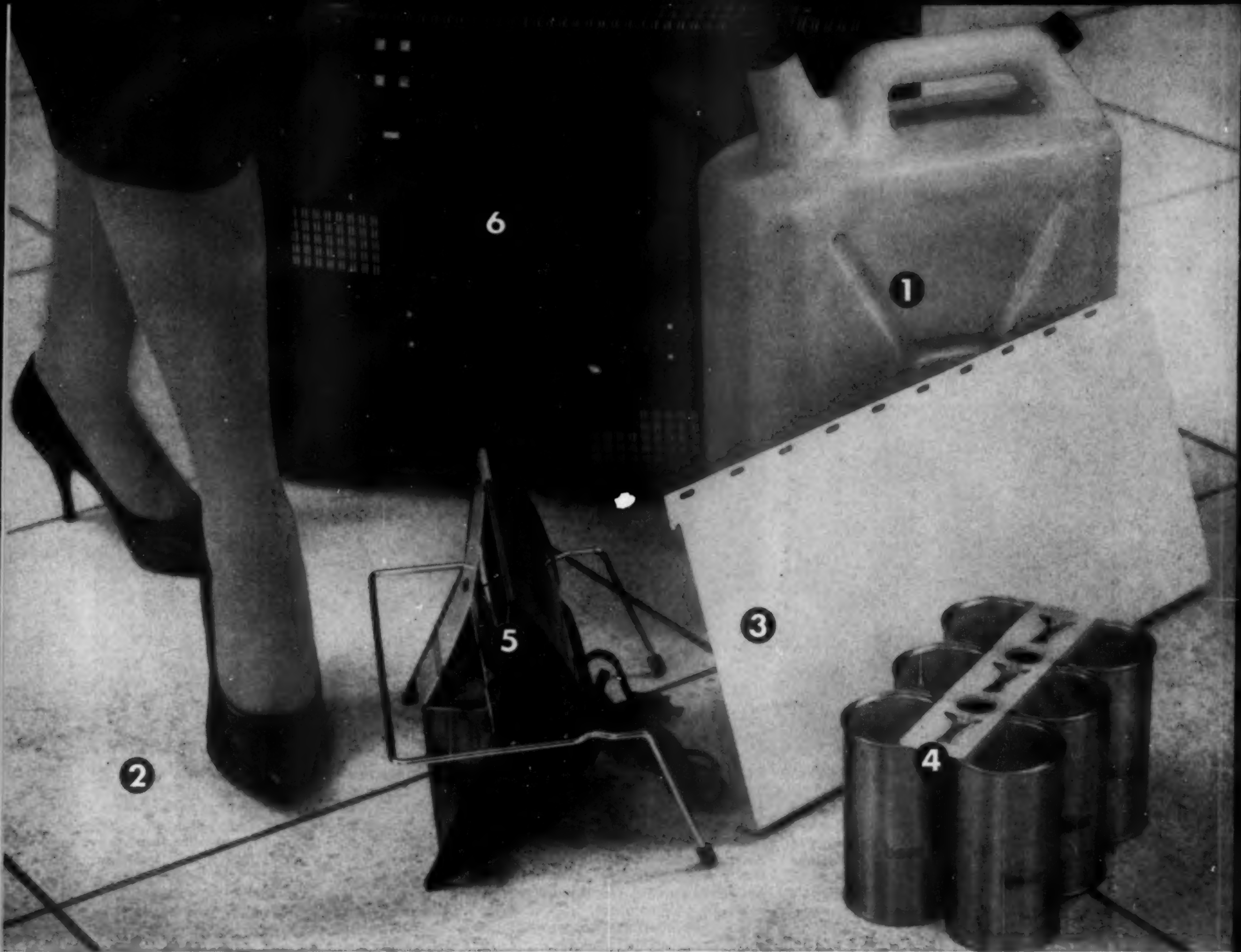
APPLICATIONS

Adding small amounts of AC Polyethylene 6 to high molecular weight resins shortens cycle times by increasing flow, improves color dispersion, improves gloss, permits use of better base resins, improves mold release, lowers pressure requirements and reduces inventory of grades needed.

Plaskon® plastics and resins are backed by the technical proficiency of Allied Chemical's applications and technical service laboratories. They are manufactured under the strictest quality controls. Write us for more information on any of these hard-working materials, or for help with design, fabrication or materials selection problems. 40 Rector Street, New York 6, N. Y.

Allied Chemical

BASIC TO AMERICA'S PROGRESS



NEW DESIGN IDEAS IN PLASTICS

(Could one of them spark the solution to your problem?)

❶ **POLYETHYLENES**—New lightweight container is ideal for a variety of liquids. Molded from BAKELITE high-density polyethylene, it is corrosion- and scuff-resistant. BAKELITE polyethylenes offer a broad range of properties: strength and sparkling clarity for film packaging, moisture- and grease-resistance for extrusion-coated packages, excellent insulating qualities for wire and cable, light weight for pipe.

❷ **EPOXIES**—Epoxy terrazzo floors have more than twice the compressive strength of concrete terrazzo. Weight is cut 75% because ¼″-thick epoxy terrazzo equals performance of 1″-thick concrete-type. BAKELITE epoxies, among the strongest and hardest plastics known, are ideal for industrial coatings, adhesives, reinforced laminates (medium-to-long-run tools and dies).

❸ **VINYLS**—Vinyl-based coatings on aluminum and steel are baked onto metal before forming. Provide excellent weather resistance with no cracking, chipping, or peeling. Offering high electrical resistance, formability, color and elastomeric qualities, BAKELITE vinyls can be easily fabricated into such products as swimming pool liners, extruded wire insulation, and as jacketing for conduits.

❹ **STYRENES**—Beverage cans effortlessly snap on and off this handsome new 6-pack carrier made from BAKELITE medium-impact styrene. Styrenes offer the designer a wide range of impact strengths, brilliant colors, glowing finishes. Molded and extruded styrenes are ideal for toys, containers, housewares, refrigerator door liners, portable TV cabinets.

❺ **PHENOLICS**—All-phenolic base housing for this newly designed sunlamp offers low heat conductivity, superior toughness. BAKELITE phenolics have high dimensional stability, very good machinability. Rich, glossy, smooth finishes. Ideal for all critical wet-dry conditions . . . and for bottle caps, chemical-resistant coatings, industrial or decorative laminates.

❻ **POLYPROPYLENES**—High heat resistance plus light weight, toughness and excellent dielectric properties, make BAKELITE polypropylenes ideal for TV backs. Outstanding chemical-, fatigue-, and stress-cracking resistance make them well-suited for pipe, housewares, auto accessories, webbing for outdoor furniture and many other uses.

For information on application of these materials and processes to your products, write Dept. JW 85J, Union Carbide Plastics Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, New York. Be sure to ask for your copy of the "Materials and Data Guide" which describes in detail the full range of BAKELITE Brand plastics.

UNION CARBIDE **PLASTICS**

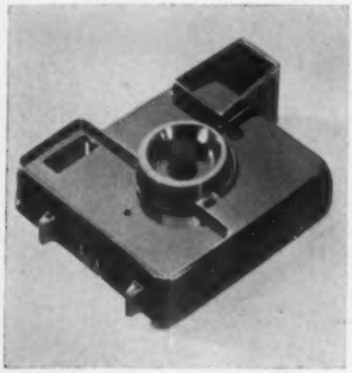
◀ For more information, circle No. 530

For more information, turn to Reader Service card, circle No. 509

DUREZ

PHENOLIC RESINS AND MOLDING COMPOUNDS
DIALLYL PHTHALATE COMPOUNDS
FIRE-RETARDANT POLYESTER RESINS
FIRE-RETARDANT RIGID FOAMS

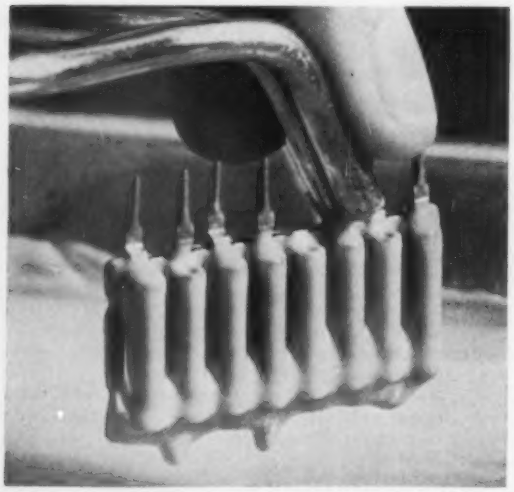
For the designer who spells



LOWER-COST general-purpose phenolics, proved in all manner of applications for forty years. These workhorses of industry account for thousands of applications—not only because they cost less but because nothing has come along that does things better: housings, cases, large and small parts requiring a balance of such properties as strength, non-conductivity, smooth surface, resistance to heat, cold, chemicals.

NON-BLEEDING PHENOLICS that are resistant to alcohol, essential oils, and other solvents and impart no color or flavor to foods, perfumes, cosmetics and other bottled products. For baby-bottle nursing top and caps we offer molding compounds which will stand repeated autoclave sterilization at 275°F, with many combinations of torque strength, surface finish, moisture resistance and other properties. They are formulated for high-speed molding on automatic presses.

GREATER IMPACT RESISTANCE for products subject to rough handling. For these Durez can help you choose from a broad range of shock-resistant phenolic compounds for telephone parts, gears, bushings, pulleys and structural components. These range from 0.3 to 17.0 ft.-lb./in. impact. With strength like this, there's no need to run up costs by overengineering or by staying with unsatisfactory materials.



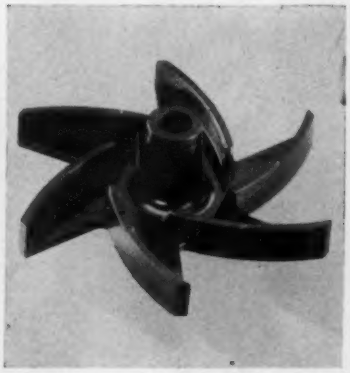
BONDING, IMPREGNATING, laminating and coating resins are also available from Durez in hundreds of formulations for use in abrasives, reconstructed wood, friction materials, rubber compounds, and corrosion-resistant mortars. Other types include shell-mold resins that are helping foundries produce better castings. Coating resins contribute important properties to printing inks, and to brushing or spraying finishes.

LARGE STRUCTURAL SHAPES such as this outboard motor shroud are stronger and safer when molded with Hetron® polyester resin and fibrous glass. Hetron laminates and molded parts do not support combustion. Fire resistance is inherent—chemically locked in without the use of weakening additives. Corrosion resistance, and the ability to take a baked-on finish without crazing, are other key qualities.

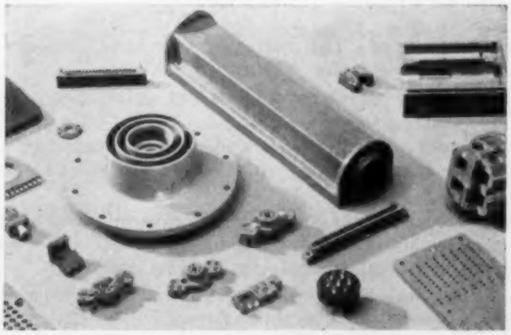
out tougher specifications...

DESIRABLE ELECTRICAL PROPERTIES, combined with light weight and dimensional stability, can be obtained in Durez electrical grade phenolic molding compounds. They find wide use in automotive ignition parts, resistor casings, coil forms, tube bases, and electronic components of many types. Some of these compounds are formulated especially for molding around large inserts. Several are designed to meet military specifications.

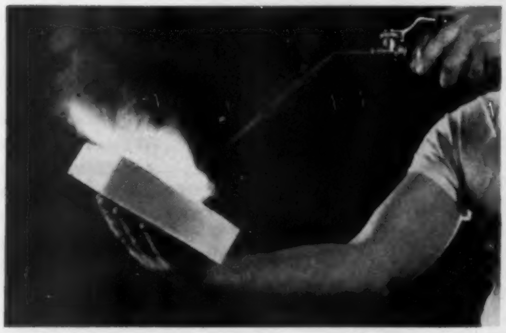
HEAT RESISTANCE combined with high non-conductivity and other desirable electrical properties is also available in Durez molding compounds. Most compounds in this class are designed to take 72-hour heat-treatment at 392°F. Some will survive 450°F for relatively long periods, and higher temperatures for shorter periods, without serious impairment of physical properties or molded appearance. They find wide use in electrical appliances.



SPECIAL PROPERTIES in unusual combinations are available in Durez phenolics. Examples: low modulus of elasticity combined with other wanted properties. Or outstanding chemical and moisture resistance combined with high mechanical strength, as in this sump-pump impeller. By formula variations and the skills of compounding learned over a forty-year period, Durez can give you resins and molding compounds that fit any job.



SPACE-AGE PERFORMANCE often requires super-plastics such as Durez diallyl phthalate molding compounds. Reinforced with orlon or glass fiber, these materials are virtually free from cold flow and creep. They retain high electrical insulation values at relative humidities above 90% and over a wide temperature range. Their reliability has led to their wide use in rocket and missile components and in many other electrical and electronic systems.



GREATER SAFETY in foamed-plastic applications becomes possible with Hetrofoam® rigid polyurethane foams. Molded into slab form, or foamed in place, these self-extinguishing materials deliver ideal properties for refrigerator insulation, building panels, pipe coverings, flotation material, and many other uses. Properties include initial k factor as low as 0.10-0.12 at 75°F, plus excellent k-factor stability.

FOR COMPLETE INFORMATION, WRITE:

DUREZ PLASTICS DIVISION

HOOKER CHEMICAL CORPORATION, 1414 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICALS PLASTICS

For more information, turn to Reader Service card, circle No. 385

Taylor

Laminated Plastics, Vulcanized Fibre, Reinforced Plastics, Molding Compounds, Pre-Impregnated Materials, Filament Wound Structures, Composite Materials, Fabricated Parts

LAMINATED PLASTICS

(Sheets, Rods, Tubes, B-stage Materials)

Phenolic Laminates. Thermosetting type. Paper, cotton fabric or mat, asbestos, glass cloth or nylon bases impregnated with phenol formaldehyde type resins. Provide dependable electrical insulation, have high dielectric and mechanical strength. Some grades are excellent basic materials for gears, cams, pinions, bearings and other mechanical applications. Asbestos grades are qualified as Class B insulation; others meet Class A requirements.

Melamine Laminates. Thermosetting type. Glass cloth or cotton fabric impregnated with melamine formaldehyde resin. These laminates have superior mechanical strength and are especially desirable for their arc resistant qualities. Good flame and heat resistance and good resistance to the corrosive effects of alkalis and most common solvents are other favorable characteristics. Classified as Class B insulation.

Silicone Laminates. Thermosetting type. Continuous filament woven glass fabric impregnated with a silicone resin. These laminates combine high heat resistance (up to 500°F., continuous) with excellent electrical and mechanical properties. Have low power factor and moisture absorption rate; very high insulation resistance and high arc resistance; excellent dimensional stability and high tensile, flexural and impact strength. Classified as Class H insulation.

Epoxy Laminates. Thermosetting type. Continuous filament woven glass fabric or paper impregnated with epoxy resin. Combine low moisture absorption with excellent chemical resistance and high mechanical strength. Characterized by good dielectric strength, low dielectric losses, and high insulation resistance even after being subjected to severe humidity conditions. Can be copper clad for production of high fidelity printed circuits.

Copper-Clad Laminates. Offer a combination of high-purity copper on superior base materials to produce printed circuits of consistently high quality. Taylor copper-clad laminates are available in several phenolic resin, paper base grades, in epoxy resin, paper or glass cloth base grades, and in specially formulated grades to meet specific requirements. All grades meet or exceed military and NEMA standards. The copper cladding is 99.5% pure and free of pinholes, pits and lead inclusions—has a high-quality finish that accepts all acid resists. All Taylor copper-clad laminates are supplied with 1, 2 or 3-oz. copper on one or both sides.

Flame-Retardant Laminates. Flame-retardant paper and glass base laminates made with special resin formulations. Have excellent moisture resistance, high electrical resistance and good mechanical properties. Offer low dielectric losses. Meet tentative Underwriters' Laboratory requirements for flame retardance.

TAYLORON REINFORCED PLASTICS

Designed to excel in the ablation and thermal insulation requirements of missiles, rockets and space craft. They are available in sheet, plate, rod, tube, molding or pre-impregnated form or as finished parts. Assemblies are not limited to the use of reinforced plastics alone, but can include metals, rubbers and other materials in combination with Tayloron reinforced plastics.

TAYLORITE VULCANIZED FIBRE

Taylorite Vulcanized Fibre is a hard, dense material with excellent physical, mechanical and electrical properties. It is tough and resilient; has high resistance to impact, abrasion, wear, organic solvents, oils and gasoline; can be machined, stamped, punched and formed; is attractive in appearance, light in weight. Available in a number of different grades, in sheets, rolls and turned rods; commercial, bone, electrical, trunk, superwhite, abrasive, track.

TAYLOR FILAMENT WOUND STRUCTURES

Available in many shapes—straight round, hexagon, square tubes, straight and reverse taper tubes and closed-end vessels, to name a few. Filaments can be laid in a number of different patterns, including level wind, helical wind, a combination of the two, and open mesh. Glass fibers are most commonly used, but such synthetics as Nylon, Dacron and Fortisan offer great promise. Epoxy, polyester, phenolic and silicone resins are available.

ENGINEERING AND FABRICATING SERVICES

New applications for Taylor materials are constantly being developed by design and production engineers in the Taylor plants. These men are available for consultation. Their experience and counsel can help you in the development of your product. Taylor's fabricating division can economically produce parts from any of the above materials. Consult us for complete details on either one or both of these Taylor services. Technical engineering data on all these products available upon request. Write Taylor Fibre Co., Norristown 45, Pa.

Taylor

LAMINATED PLASTICS • VULCANIZED FIBRE

For more information, turn to Reader Service card, circle No. 420

GEON® VINYLS

Look how many ways this versatile plastic performs! As a soft, flexible material, Geon vinyl provides an excellent combination of properties, either by itself or in combination with other materials. Geon provides inertness or resistance to chemical attack, acids, alcohols, oils and alkalies—as well as providing superior electrical properties, and resistance to abrasion and weathering. Extruded, molded or used as a coating on metal, wood, paper or other materials, Geon offers outstanding opportunity to create new products or improve old ones.

In rigid form, Geon provides the same basic properties, with structural advantages added. For example, rigid Geon is used in many building applications—as sash, moldings, coving or decorative sheet. Rigid Geon pipe and conduit provide corrosion-resistant advantages resulting in far longer, trouble-free life. Rigid Geon extrusions can offer weight-carrying potential.

HI-TEMP GEON™

hi-temp Geon offers the advantages of vinyl but performs at 215°F, 60°F higher than the operating temperatures of previous rigid vinyls. This new addition to the Geon vinyl family can be used in the same way as any of the other uses of Geon — for extrusion, molding and calendering.

Complete information telling about the many ways hi-temp Geon can help improve a product or open whole new markets is readily available. Write for it.

Physical properties of typical Geon vinyls
A Rigid Compound (Geon 8700-A)

Specific gravity	1.35
Hardness (Durometer D)	78
Tensile strength (psi)	6200
Impact strength (Izod—ft. lbs. per inch notch)	15
Flexural strength (psi)	11,500
Compressive strength (psi)	8600
Heat distortion (at 264 psi—F°)	157

Physical properties of hi-temp Geon high-impact compound (Geon 88805)

Specific gravity	1.5
Hardness (Rockwell R)	117
Tensile strength (psi)	7800
Impact strength (Izod—ft. lbs. per inch notch)	5
Flexural strength (psi)	14,500
Heat distortion (at 264 psi—F°)	215
Elongation at break (%)	4.5

Flexible Materials

Geon resins are used to make many different kinds of flexible materials. According to the formulation employed, physical properties can be obtained to meet widely varying requirements. Softness, flexibility, specific gravity, abrasion resistance, electrical properties, chemical resistance, adhesion to various substrates, all can be altered and controlled. As a result, flexible Geon vinyl compounds are found in such varied products as garden hose, life preservers, shoe soles, dolls, refrigerator door gaskets, playballs, electrical insulation, cable jacketing and interior coatings on dishwashers.

The mark of similarity shared by all these members of the family of plastics from B.F.Goodrich Chemical—all provide high uniformity and reliability of unusual value. For more information or for help in applying these materials to your product, write Department NN-8, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. In Canada: Kitchener, Ontario.

B.F.Goodrich Chemical
a division of The B.F.Goodrich Company

For more information, turn to Reader Service card, circle No. 446

MESA
HIGH RELIABILITY MOLDING COMPOUNDS

"DIALL"

Diallyl Ortho-Phthalate

50-01 Orlon Filler in this compound provides shock resistance and excellent electrical stability at high temperatures with 100% humidity. MIL-M-14F Type SDI-5.

50-51 Dacron fiber filler increases toughness to three times that of 50-01 compound and further improves moisture resistance... for rough usage. MIL-M-14F Type SDI-30.

50-52 All the advantages of 50-51 plus increased FLAME RESISTANCE... the shock resistance of Dacron filled compounds is exceptional. MIL-M-14F Type SDI-30.

51-01 An Asbestos-filled compound combining economy with very good dimensional stability and resistance to heat and moisture. MIL-M-14F Type MDG.

775 Mineral-filled molding compound for general-purpose use and economy, with Nylon fibers added to provide increased impact strength. MIL-M-14F Type MDG.

52-01 A short glass fiber-filled compound providing the physical and electrical advantages of the glass filler in a granular form that can be molded in automatic presses. MIL-M-14F Type SDG.

52-70-70 Comparable to 50-01, plus increased FLAME RESISTANCE.

52-20-30 Excellent electrical characteristics are provided in this high impact material which incorporates a long glass fiber filler. MIL-M-19833 Type GDI-30.

52-40-40 Long glass fiber filler-type molding compound with increased FLAME RESISTANCE.

28 A puttylike long glass fiber-filled compound which can be molded at relatively low pressures, producing void-free parts, even in heavy sections. MIL-M-19833 Type GDI-30.

Diallyl Meta-Phthalate

FS-4 High impact resistance and fine electrical properties of the long glass fiber filler in this compound are enhanced by use of diallyl meta-phthalate resin base which increases heat resistance. MIL-M-19833 Type GDI-30.

FS-80 Long glass fiber filler and higher heat resistant resin base in a compound affording FLAME RESISTANCE. MIL-M-19833 Type GDI-30F.

FS-5 A glass-filled compound in granular form... can be molded in automatic presses to make strong, heat-resistant parts. MIL-M-14F Type SDG.

FS-10 FLAME RESISTANCE and heat resistance are major advantages of this glass-filled granular compound. MIL-M-14F Type SDG.

FS-6 Asbestos-filled, general-purpose compound with high arc resistance and high heat resistance. MIL-M-14F Type MDG.

FS-60 General-purpose Asbestos-filled molding compound with high heat resistance plus FLAME RESISTANCE.

"EPI-ALL"

Conventional Molding Grade Epoxy Compounds

1038 A Dacron and glass-filled epoxy molding compound with toughness, good moldability and heat resistance.

1150 General-purpose epoxy molding compound... granular, with mineral and glass filler.

1288 High impact glass fiber-filled epoxy molding compound provides low weight loss at temperatures as high as 500°F.

1459 A jet-black, semi-soft epoxy molding compound with mineral and glass filler for general-purpose applications.

Encapsulation Grade Epoxy Molding Compounds

1585 Pressures as low as 50 psi can be used to mold this epoxy compound around delicate inserts for encapsulation of components with fine wires, etc.

1606 Can be molded as precisely as 1585 ...and improved FLAME RESISTANCE is incorporated in this compound.

"POLY-ALL"

Alkyd Molding Compounds

880 Long glass fiber filler provides high impact resistance in an economy compound with good dimensional and electrical stability.

1408 A mineral and glass-filled putty compound with good physical and electrical properties and a fast cure rate.

NEW AND UNIQUE DEVELOPMENTS

"Diall" 1610 An ELECTRICALLY CONDUCTIVE plastic with a resistance of .4 ohms/cm. The flush molded printed circuit board is one of many areas of application.

BF-80 A MAGNETIC PLASTIC which can be magnetized either wholly or in specifically desired areas of the molded piece... can be used wherever magnetic properties are required.

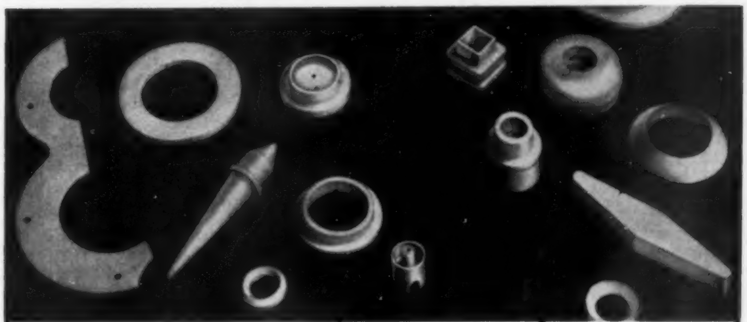
For further details concerning any of the above molding compounds please write direct:

MESA DIALL

MESA PLASTICS COMPANY Western Plant: 12270 Nebraska Ave., Los Angeles 25, Calif. BR 2-4471 • Eastern Plant: 100 Lambert Ave., Copiague, Long Island, New York TU 4-4055

For more information, turn to Reader Service card, circle No. 408

PLASTICS
in Design Engineering



PROPERTY	TEFLON (TFE)	TEFLON (FEP)
Specific Gravity	2.1-2.2	2.1-2.2
Tensile Strength, 73°F	2500-3000 psi[a]	2700-3100 psi
Elongation, 73°F	100-200%	250-330%
Compressive Stress at 1% Offset	1000 psi	700 psi
Impact Strength, Izod Notched, 77°F	3.0 ft. lb./in. of notch	Does not break
Heat Distortion Temp., 66 p.s.i.	270°F	162°F
Coefficient of Linear Thermal Expansion (Approximate Values per °F)	5.5×10^{-5} in./in./°F	5.23×10^{-5} in./in./°F
Dielectric Strength, Short Time, 1/16"	400-500 v/mil[b]	400-500 v/mil[b]
Surface Arc-Resistance	700 seconds[c]	165 seconds[d]
Volume Resistivity	$>10^{15}$ ohm-cm.	2×10^{15} ohm-cm.
Dielectric Constant (60 Cycles)	2.0	2.2
Service Temperature Range (Max.)	+500°F	+400°F
Service Temperature Range (Min.)	−395°F	−395°F
Water Absorption	0.0%	0.0%
Flammability	Nonflammable	Nonflammable

(a) Tensile strength in oriented film may be as high as 15,000 psi.
(b) Value is 1000-2000 v/mil in thicknesses of 5 to 12 mils.
(c) Does not track.
(d) Samples melted in arc after 15 seconds, but did not carbon track.

This table compares the properties of Teflon* TFE and FEP. The newer FEP can be injection molded. In designing, consult your Garlock plastics specialist for best application results.

In designing intricate parts, consider the benefits of Teflon as a material.

Teflon offers a unique combination of properties unmatched by other plastics. It possesses the lowest coefficient of friction, the best non-stick characteristics, the most complete chemical resistance and the widest useable temperature range available in any plastic. Teflon eliminates lubrication, corrosion, contamination, seizing; it reduces friction, wear, space required, weight. Teflon can be used in a thousand different ways—for packings, gaskets and seals . . . for connectors, insulators, and test points . . . for valves, bearings, couplings, and insulation.

In producing intricate Teflon parts, consider the benefits of Garlock as a supplier. From virgin powder to finished piece, Garlock closely controls each step in the process to assure that the final part performs to your expectations. Complete facilities are at your disposal for molding, extruding, and machining of Teflon. If your application calls for special properties, Garlock will compound Teflon with selected fillers to greatly extend its service range. If you need unusually large configurations, Garlock will fusion-weld Teflon . . . the weld will have the same thermal, chemical and electrical properties as the Teflon itself.

Parts made from Nylon, Delrin*, C.T.F.E., Lexan† are also available from Garlock. Let your local Garlock representative quote on your design, or ask his assistance on any design problems concerning materials and applications. Call him at the nearest of the 26 Garlock sales offices throughout the U.S. and Canada. Or, write for Catalog AD-177. Garlock Inc., Palmyra, N.Y.

GARLOCK

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Company

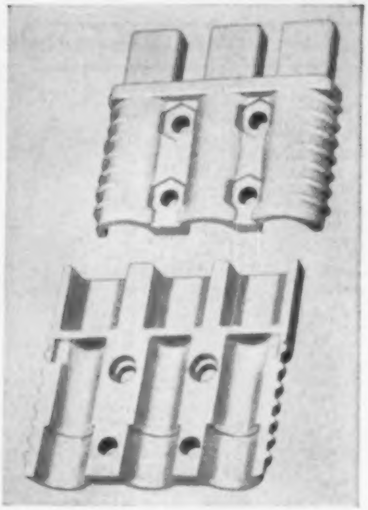
Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

*DuPont Trademark
†General Electric Trademark

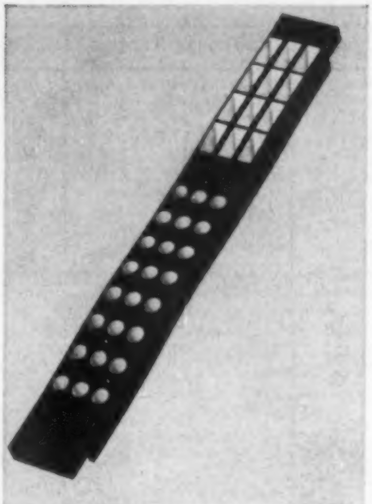
For more information, turn to Reader Service card, circle No. 388

G-E LEXAN® POLYCARBONATE RESIN

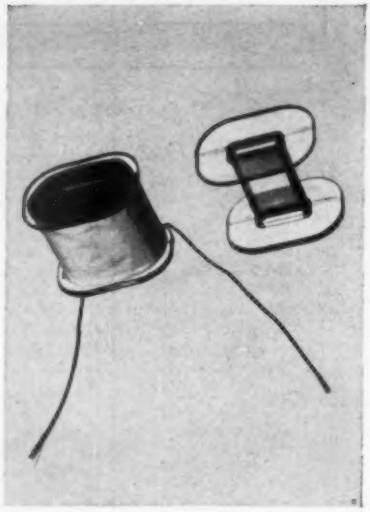
TOUGHEST OF PLASTICS!



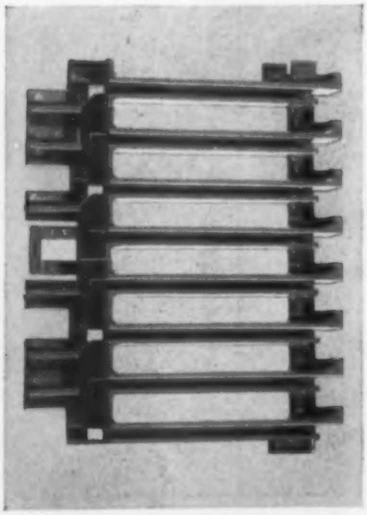
STRENGTH LEXAN resin has an impact strength of more than 12 foot-pounds per inch of notch — higher than any other plastic! This toughness, plus heat resistance and good electrical properties, make LEXAN resin an outstanding choice for 3-pole connectors used in rugged service on electric trucks.



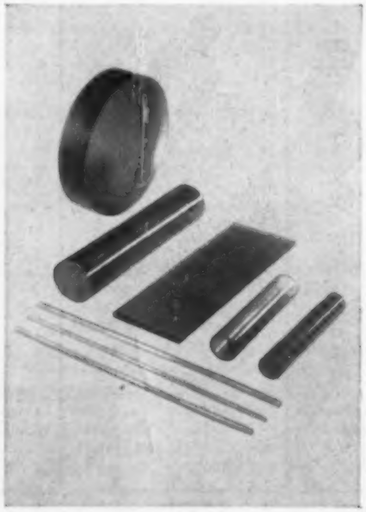
HEAT STABILITY Lampholder terminal block is used inside electronic equipment where heat is difficult to dissipate. LEXAN polycarbonate resin replaced another thermoplastic which melted under severe thermal conditions. LEXAN has a heat distortion point as high as 290°F. Also keeps high strength in sub-zero cold.



ELECTRICAL PROPERTIES A good dielectric, LEXAN resin is non-corrosive even when used with very fine Class F magnet wire. Coil forms must not distort at temperatures above 200°F under stresses caused by tightly wound wire. LEXAN resin provides high heat distortion temperatures under load.



DIMENSIONAL STABILITY Card Guide for business machines is molded to close tolerances . . . must undergo minimum change in dimensions during service. Parts show excellent dimensional stability under moist and high temperature conditions. LEXAN resin meets self-extinguishing requirement.



TRANSPARENCY Stock shapes and film of LEXAN polycarbonate resin have excellent transparency. Bar stock is easily machined; film can be thermoformed, heat-sealed and solvent-sealed. Combination of clarity, toughness and malleability gives LEXAN resin the design capabilities of a transparent metal!

LEXAN OPENS UP NEW OPPORTUNITIES... Even before LEXAN entered large-scale production, manufacturers, impressed by its exceptional properties, developed and field tested over 300 applications. G.E. participated in these developments. With the opening of new G-E facilities capable of producing millions of pounds of LEXAN per year, the price of this versatile thermoplastic has dropped dramatically — over 40% in a single year. This fact alone has brought many new products within the range of feasibility. Can you afford to overlook the opportunities presented by LEXAN? Send for details on price, properties, applications and G-E's technical assistance program today! General Electric, Chemical Materials Department, Section **E-21**, Pittsfield, Mass.

LEXAN®
Polycarbonate Resin

GENERAL ELECTRIC

For more information, turn to Reader Service card, circle No. 469

QUALITY Glidden PRODUCTS

GLIDPOL
POLYESTER RESINS

For Laminating, Impregnating, Molding, Casting and Protective Coating

HOW TO SELECT THE RIGHT GLIDPOL RESIN FOR YOUR APPLICATION

This tabulation includes formulations which have proven themselves to be most suitable for current fabricating procedures. Our plastics laboratories continue to develop improved formulations that do a better job for standard and new fabricating procedures. Data sheets on individual resin systems are available.

Additional resins available for special applications

GLIDPOL POLYESTERS	1001	1001-A	1001-LS	1008	1012	1017	1026	1027	1032	1042
Liquid Properties Styrene	X	X	X	X	X	X	X	X	X	X
Viscosity (1)	M	M	M	M	M	M	M	M		
Thixotropic									X	X
Curing Characteristics Preaccelerated for Room Temp.										
Cure									X	X
Air Dry			Any with Glidpol 3305 added							
Cured Characteristics										
Rigid	X	X	X	X	X	X	X	X	X	X
High H.D.T.					X	X		X		
Light Stabilized			X							
Applications Casting and Potting	X	X		X						
Contact Molding	X	X	X			X			X	X
Matched Die Molding			X		X	X	X			
Premix Molding					X	X	X	X		
Laminating	X	X	X		X	X				
MIL-R-7575A	X				X	X				

(1) M – (Medium) 500-3000 cps.

GLIDDEN LEADERSHIP IN POLYESTERS AND GEL-KOTE

Experience—Glidden is one of the largest polyester resin producers in the country (1961 capacity 72,600,000 pounds) and the leading producer of Gel-Kote. Here are some examples of recent Glidden development breakthroughs:

1957—Thixotropic resin—prevents resin drainage, yielding laminates with uniform resin-glass distribution;

1957—Dual gun resins—matched resin systems designed for high speed production operations involving resin-glass spray-up guns;

1958—Acrylic Gel-Kote—high color and gloss retention even under severe weather conditions;

1959—Isophthalic resins—excellent handling characteristics, toughness and adhesion;

1961—High strength resins—improved resin systems which produce reinforced structures with up to 50% higher physical strength.

Continuing research—To provide specific custom product development on the local level, Glidden maintains 13 regional laboratories, plus a Research Center for long-range development.

Technical service—Strategically located representatives back up Glidden salesmen in the solution of day to day technical problems.

Nation-wide production facilities—Glidden produces resins and Gel-Kote at 7 plants located in all parts of the country. This means fast delivery, custom formulating facilities close at hand.

RESINS FOR EVERY APPLICATION

The Glidden Company
INDUSTRIAL PAINT DIVISION
900 Union Commerce Building • Cleveland 14, Ohio
In Canada: The Glidden Company, Ltd., Toronto, Ontario

There's a GLIDPOL Polyester Resin system plus Glidden Technical Service, to help you do it better, more economically, whatever your product, process or problem.

REGIONAL SALES OFFICES

Atlanta	Los Angeles	Reading
Chicago	Minneapolis	San Francisco
Cleveland	New Orleans	St. Louis

Canada: Toronto, Montreal

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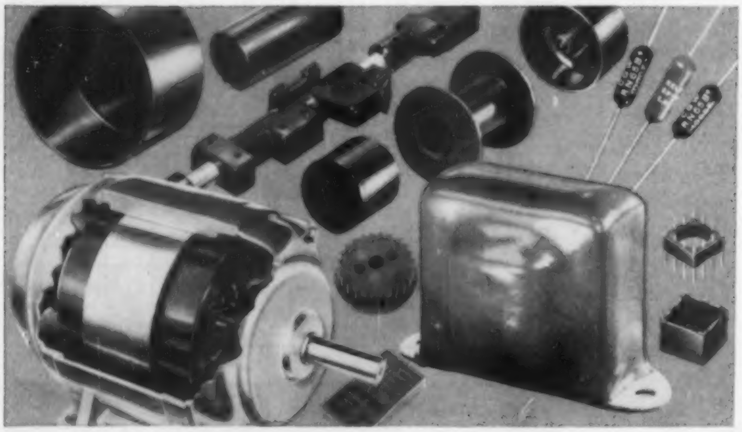
America's Pioneer Manufacturer of Epoxy Insulation, Adhesive, Tooling Compounds

YOUR BEST SOURCE OF EPOXY-BASED ELECTRICAL-ELECTRONIC INSULATION



Hysol, pioneer manufacturer of epoxy compounds for electrical insulation, offers you a complete line of epoxy dipping, casting, molding and conductive compounds. Hysol Epoxy compounds provide exceptional dielectric properties, flame-out and flame retardant and resistance; high adhesion; and controlled dimensional stability. Available in operating classes A to H.

You may choose from a series of proven compounds or, upon consultation, Hysol will develop or modify a compound to meet your needs.

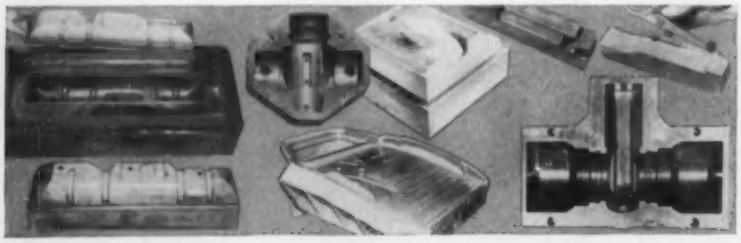
To assist you in the selection of a Hysol compound to fill your needs, write for Bulletin E-100.

HYSOL EPOXY ADHESIVES OFFER MANY UNIQUE PROPERTIES

A complete line of high-strength chemically resistant room temperature and heat cure epoxy adhesives. Available in one- and two-component systems to bond metal to metal, glass, wood, most plastics.

Also available in easy-to-use Epoxi-Patch Kits in a full range of colors and as a room cure adhesive.

There's a HYSOL Epoxy adhesive or modification to fill your demand. Write for Adhesive Bulletin A-100 for more complete information.



HYSOL EPOXY TOOLING CAN SAVE YOU MONEY

Hysol offers a complete line of epoxy tooling compounds to provide you with tough, dimensionally stable, economical production and prototype tooling. Manufacturers now using Hysol tooling systems save 50 to 75% or more.

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SILICOLOGY

Studies in Silicones

HOW THESE TIME-TESTED MATERIALS CAN WORK FOR YOU

New Silicone Rubber Compounds Now Can Be Molded to Closest Tolerances

Looking for durable rubber compounds that offer precision molding, reliability, and flexibility over a wide temperature range—where other materials have failed?

Here is one example of how silicone rubber compounds came into existence to fill these requirements, through cooperation between Silicones Division engineers and their customers.

Sierra Engineering Company, Sierra Madre, Calif., had a new emergency oxygen mask under development for passengers on today's high-altitude, high-speed jet airliners. They needed a rubber material with these properties:

1. Resiliency to spring back to shape after folded storage.
2. Softness to conform to facial contours.
3. Extremely low oxygen permeability.
4. Good color dispersion.
5. Non-irritating, non-allergenic properties.
6. No smoke or fume problems during post-cure.

COOPERATIVE ENGINEERING

The Union Carbide Silicones Man brought these and other requirements back to his team of associates in R&D.

Prior to this, the combined technical and research facilities of Union Carbide Corporation, with tremendous resources of chemical experience and knowledge, had already achieved a long list of "firsts" in silicone rubber, including:

A controlled reactivity, vinyl-containing silicone rubber. A non-volatile catalyst system for one-step curing of thick sections. Electrically conductive silicone rubber. A rubber for electrical tapes, hot-air ducting, and other wrapped constructions. A compound to meet Naval cable specifications for atomic submarines. And the first and only silicone rubber compound qualified for automotive rear pinion seals.

FROM UNION CARBIDE—first commercial silicone compound for high-altitude emergency oxygen masks.

MEETING BASIC PRODUCTION PROBLEMS

For Sierra's oxygen masks, the principal properties needed had all been met before, *but not in a single silicone rubber compound*. Working closely with Sierra, engineers of the Silicones Division succeeded in formulating a compound that matched the needs and answered all basic production problems as well.

The new compound permits molding to extremely close tolerances. Its purity means freedom from smoke and fume problems during post-cure. It more than meets Sierra's strict quality controls, including complete performance test records on every mask produced. And the same compound is now also being used for Sierra's oxygen masks designed for military jet pilots and the crews of commercial planes.

MAIL COUPON FOR DATA

If your designing calls for rubber with advantages such as low temperature flexibility, thermal and oxidation stability at very high temperatures, low compression set, weather, ozone, oil resistance, electrical resistance or conductivity, your Silicones Man has them at his finger tips. The coupon below will bring your problems to his immediate attention.

UNION CARBIDE

SILICONES

UNION CARBIDE is a registered trade mark of Union Carbide Corporation.

SIERRA ENGINEERING COMPANY of Sierra Madre, Calif., tests every silicone rubber mask it manufactures and maintains an accurate serial number check to be sure the quality is uniform at all times.

Silicones Division
Union Carbide Corporation
Dept. JM-9101
30-20 Thomson Ave., Long Island City 1, N. Y.
***In Canada:* Union Carbide Canada Ltd., Bakelite Division, Toronto 12.**

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SUPPLIERS' LITERATURE

Plastics and Rubber

cont'd from p 168

tics Dept., 11 pp. Information on reinforced plastics molding compounds, and impregnated and unimpregnated felts, papers and fabrics. **93**

Machining Reinforced TFE. Rogers Corp., 2 pp, No. 127. Recommended methods of machining reinforced TFE materials, including information on handling, tools and work set-up, heavy machining, drilling, reaming, tapping, and finish grinding. **94**

Plastics Laminates. Spaulding Fibre Co., Inc. General descriptions, characteristics, and specifications of 15 different phenolic, epoxy, melamine, and polyester fire resistant industrial plastics laminates. Includes information on copper-clad materials. **95**

Plastics Laminates. Taylor Fibre Co., 8 pp, illus. Information on available grades; specifications; colors; sizes; physical, mechanical and electrical properties; and typical applications of various plastics laminates and vulcanized fibre. **96**

Plastics Data. Union Carbide Plastics Co., Div. of Union Carbide Corp., 12 pp, illus., No. J-2110. Advantages, characteristics, properties, uses, and other information on polyethylene, epoxy, phenolic, styrene, and vinyl plastics. **97**

Silicones. Union Carbide Corp., Silicones Div., 16 pp, illus., No. SF-1000C. General information on what silicones are and where they are used. Specific discussions on physical, mechanical and electrical properties, and typical uses in electrical and electronic equipment; aircraft and missiles; appliance, automotive and metal working production; textile, paper, glass, and plastics fabrications; rubber products; etc. **98**

Sponge Rubber. U. S. Rubber Co., U. S. Kem-Blo Sponge Dept., 4 pp, illus. Applications, dimensions and specifications for various types of sponge rubbers. **104**

Plastics Laminates. Westinghouse Electric Corp., Micarta Div., 20 pp. Series of data sheets give complete properties, typical applications, specifications, tolerances, selection guides, sizes and thicknesses, and other information on various types of plastics laminates. **99**

Urethane Foams. Witco Chemical Co., Inc., 22 pp, Nos. F-1, 2 and 3. Information on polyester resins for use in the production of flexible and rigid urethane foams. **105**

SUPPLIERS' LITERATURE

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Synthetic Fiber Felts. American Felt Co., 8 pp, No. 4-61. General, physical, mechanical, and chemical properties; and typical uses of over 20 grades of industrial and mechanical synthetic fiber felts. Includes polyester, polypropylene, rayon, acrylic, nylon, and teflon materials. **106**

Ceramics. American Lava Corp., Steatite Div., 24 pp, illus., No. 561. General information on technical ceramics, properties and uses. **107**

Chrysotile Asbestos. Lake Asbestos of Quebec, Ltd., American Smelting & Refining Co. Advantages, characteristics, properties and applications of chrysotile asbestos. **108**

Fibers. American Viscose Corp., Rayon & Film Div., 50 pp, No. 5005. Properties of synthetic and natural fibers; glossary of textile terms; spinning twist calculator; denier conversion table; packaging data; and products, services, trademarks and other information on fibers. **109**

Rubber, Plastics O-Rings. Auburn Mfg. Co., 20 pp, illus. Design data, properties and sizes of o-rings made of natural and synthetic rubber and plastics. **110**

High Temperature Ceramic Fiber. Carborundum Co., Research & Development Div., 8 pp, illus. Properties, available forms and current uses of a ceramic fiber designed to withstand operating temperatures up to 2300 F. **111**

Properties of Felt. Continental Felt Co., 12 pp, illus. General, physical, mechanical, and chemical properties; fabricating methods; typical uses; relative prices and an alphabetical list of hundreds of felt applications keyed to specific properties. **112**

Properties of Glasses. Corning Glass Works, Technical Products Div., 16 pp, No. B-83. General information on types of glasses available, and specific information on such things as mechanical, electrical, thermal, and optical properties; heat transmission; corrosion resistance; and viscosity. **114**

Silicones in Aircraft. Dow Corning Corp., 8 pp, illus., No. 1-117. Properties and typical uses of silicone fluids, rubber, potting materials, sealants, and protective coatings in aircraft and missiles. **115**

TFE-Coated Fabrics. E. I. du Pont de Nemours & Co., Inc., Fabrics & Finishes Dept., Fabrics Div., 4 pp. Mechanical, chemical and thermal properties, formability and uses of TFE-fluorocarbon resin-coated glass fabrics and laminates. **116**

Felt Design Book. Felters Co., 24 pp. Information on design properties of felt, descriptions of special treatments, and data on how to select the proper shapes and dimensions for specific applications. Also included are data on felt lubrication seals, gaskets, wicking and filters. **117**

Metallizing Ceramics. Globe-Union Inc., Centralab Electronics Div., 1 p, illus., No. CB-1030. Information on design, engineering considerations, properties, and applications of steatite and high alumina ceramics for low and high temperature metal-to-ceramic seals. **118**

Graphite. Graphite Specialties Corp., 4 pp, No. GS-101-1. Chemical and physical properties of an impervious graphite for high temperature parts. **119**

Graphite. Great Lakes Carbon Corp., Electrode Div., 8 pp, illus. Outstanding characteristics, chemical composition, properties, and typical applications of graphite in atomic energy, metallurgy, metal fabricating, aircraft and missiles, chemical processing, etc. **120**

Synthetic Sapphire. Industrial Sapphire Co., 4 pp, illus. General description of synthetic sapphire materials, typical uses, and physical, mechanical, thermal, and electrical properties. **121**

Cemented Carbides. Kennametal, Inc., 16 pp, illus., No. B-777. General information, advantages, characteristics, typical uses, and other information on a hard cemented carbide with high rigidity. **122**

Specialty Papers. Knowlton Bros., Inc., 12 pp, illus. Information on technical and industrial specialty papers. Shows company research and manufacturing facilities. **123**

Engineered Glass Parts. Kopp Glass, Inc., 20 pp, No. 760. Services and facilities available for the production of colored and clear glass parts. Included are examples of sizes, colors, designs and custom-engineered glass products. **124**

Industrial Ceramics. McDanel Refractory Porcelain Co., 16 pp, illus., No. P561. Sizes, specifications, uses, and properties of such ceramic materials as alumina, mullite, chemical and electrical porcelains, etc. **125**

Ceramoplastic, Mica Insulation. Mycalex Corp. of America, 36 pp, illus. Advantages, characteristics, properties, uses, design information, and other data on molded and fabricated ceramoplastics and glass-bonded mica; synthetic mica; and other electrical and electronic materials. Includes a comparison property chart. **127**

Carbon and Graphite. Ohio Carbon Co., 8 pp, illus., No. 1164A. Composition, characteristics, properties and applications of carbon and graphite. **128**

Glass Fiber Insulation. Pittsburgh Plate Glass Co., Fiber Glass Div., 4 pp, illus. Advantages of using glass fibers for sound and heat insulation applications. **129**

Coated Fabrics. Reeves Bros., Inc., Vulcan Div., 12 pp, illus. Advantages, characteristics, uses, properties, sizes, tolerances, and other information on various types of industrial coated fabrics. **130**

Industrial Ceramics. Saxonburg Ceramics, Inc., 20 pp, illus. Electrical and mechanical properties, design considerations, advantages, and characteristics, fabrication data, chemical analyses, sizes and tolerances, and other information on steatite, forsterite, cordierite, alumina, porcelain, and other ceramic materials. **131**

Carbon and Graphite. Speer Carbon Co., Carbon Products Div. Properties, characteristics, sizes, typical uses, and other information on several grades of carbon and graphite for high temperature applications. **132**

Heat Reflection. Thermo-Chem Corp., 4 pp. High and low temperature barrier capabilities, strength, abrasion resistance, and other information on a process capable of imparting heat reflection properties to ordinary textiles, fabrics, paper, felt, rubber, plastics, and leather. **134**

Synthetic Fiber Felts. Troy Mills, Inc., Industrial Div., 8 pp, illus. Strength, dimensional stability, wear, moisture and chemical resistance, and uses of a nonwoven synthetic fiber felt. **135**

Carbon, Graphite Materials. National Carbon Co., Div. of Union Carbide Corp., 8 pp, illus., No. S-5425. Advantages, characteristics, properties, typical applications, design data, selection guides, and other information on carbon, graphite, and carbon-graphite combinations. **136**

Treated Felts. Western Felt Works. Properties and uses of felts treated with TFE, polyester and polyethylene resins. Contains samples. **137**

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OTHER NONMETALLICS

OTHER NONMETALLICS

Mechanical and Electrical Ceramics—Fired Parts

Type →	Polycrystalline Glass (Pyroceram) 9606	Polycrystalline Glass (Pyroceram) 9608	Cordierite	Forsterite
PHYSICAL PROPERTIES				
Specific Gravity	2.60	2.50	2.29–2.65	2.9
Ther Cond, Btu/hr/sq ft/°F/ft	2.10	1.14	0.97–2.40	1.94–2.40
Coef of Ther Exp, per °F				
68–212 F	4.0×10^{-6}	$0.22–1.1 \times 10^{-6}$	2.08×10^{-6}	4.72×10^{-6}
68–570 F	3.16×10^{-6}	$0.22–1.1 \times 10^{-6}$	—	—
68–932 F	2.7×10^{-6}	$0.4–1.1 \times 10^{-6}$	1.68×10^{-6}	5.40×10^{-6}
Thermal Shock Resistance	Good	Good	Good	Moderate
Water Absorption, %	0.00	0.00	0.02–3.2	0.00–0.02
Gas Permeability	Gas-tight	Gas-tight	—	Gas-tight
Specific Heat, Btu/lb/°F	0.185	0.190	—	—
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	17.3×10^{6}	12.5×10^{6}	7×10^{6}	—
Mod of Rupture, 1000 psi	20	16–23	6.8	19
Tensile Strength, 1000 psi	—	—	3.0	10
Hardness (Knoop)	698[d]	703[d]	7	7.5
Impact Strength (Charpy), in.-lb				
¾ In. Dia	—	—	7.4	7.5
½ In. Dia	—	—	4.4	2.4–4.0
Compressive Strength, 1000 psi	—	—	52–95	80–85
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm				
68–77 F	2×10^{16}[b]	6.3×10^{13}[b]	$>10^{14}$	$>10^{14}$
212 F	1.6×10^{13}	1.3×10^{11}	—	5.0×10^{13}
482 F	10^{10}	1.26×10^{8}	—	—
572 F	2×10^{9}	2×10^{7}	—	7.0×10^{11}
662 F	5×10^{8}	6.31×10^{6}	—	—
932 F	2×10^{7}	3.1×10^{5}	—	1.2×10^{10}
1292 F	—	—	—	1.0×10^{8}
1652 F	—	—	—	3.0×10^{6}
Dielectric Strength, v/mil	250–350	—	140–230	250
Dielectric Constant				
60 Cycles	5.62[c]	7.13[c]	—	6.3
1 Mc	5.58	6.78	4.02–6.23	6.2–6.5
100 Mc	5.52	6.55	—	6.1
10,000 Mc	5.45	—	—	5.8
Dissipation Factor				
60 Cycles	0.0016[c]	0.020[c]	—	0.0014
1 Mc	0.0015	0.0030	0.0010–0.00930	0.0002–0.0004
100 Mc	—	—	—	0.0003
10,000 Mc	0.00033	0.0068	—	0.0010
Loss Factor				
60 Cycles	0.009[c]	0.14[c]	—	0.009
1 Mc	0.009	0.026	0.0297–0.0579	0.001–0.002
100 Mc	—	—	—	0.002
10,000 Mc	0.002	0.045	—	0.0058
T_e Value, F[e]	1400[b]	815[b]	1436	680–>1832
Temp Coef of Capacitance Chg[f]	—	—	420	—
HEAT RESISTANCE				
Max Rec Svc Temp, F	—	—	—	1832
USES	Developed for uniform electrical properties in missile radomes; suitable for high temperature, high frequency applications in electronics	General purpose; line of heatproof cooking-serving ware; telescope mirror blanks	Aircraft firewall connectors, appliance coil supports and terminal blocks, automotive heater cores, hot point insulators, brazing fixture parts, foundry parts, fuel burner tips, thermostat controls	Very low loss insulators, ceramic-to-metal seals (close tolerances obtainable by grinding)

[a] Alumina properties are on "Refractories" pages. [b] Extrapolated. [c] 100 cycles. [d] Knoop hardness at 100 gm.
[e] Te value is the temperature at which a cubic centimeter of the material has a resistance of 1 megohm. [f] 77–185 F, parts per million.

Mechanical and Electrical Ceramics—Fired Parts

Type →	Standard Electrical	Refractory Mullite	Steatite	Zircon
PHYSICAL PROPERTIES				
Specific Gravity	2.37–2.53	3.0–3.3	2.5–2.92	3.43–3.86
Ther Cond, Btu/hr/sq ft/°F/ft	0.87–1.57	1.38–1.45	1.45–1.94	2.88–3.61
Coef of Ther Exp, per °F				
68–212 F	2.00×10^{-6}	$2.7\text{–}3.0 \times 10^{-6}$	$3.33\text{–}3.99 \times 10^{-6}$	$1.31\text{–}1.84 \times 10^{-6}$
68–932 F	2.70×10^{-6}	—	$4.52\text{–}5.50 \times 10^{-6}$	$2.09\text{–}2.16 \times 10^{-6}$
Thermal Shock Resistance	Fair	Good to excellent	Moderate	Good
Water Absorption, %	0.0–0.1	0.00	0.0–1.0	0.0–9.0
Gas Permeability	Gas-tight	Impervious	—	—
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	10×10^{6}	—	$13\text{–}16 \times 10^{6}$	21×10^{6}
Tensile Strength, 1000 psi	2.5–7.0	14–18	4.8–15	4.5–12
Hardness (Mohs)	7.0–7.5	7.5–9.0	7.5	8
Impact Strength (Charpy), in.-lb				
¾-In. Dia	8.2	—	10.5–14.0	8.9–11.4
½-In. Dia	—	—	3.8–5.0	5.50–5.64
Flexural Strength, 1000 psi	5.4–12.0	—	11–20	18.5–22.0
Compressive Strength, 1000 psi	49.1–70.0	100–150	66–90	60–100
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm				
68–77 F	$10^{13}\text{–}10^{15}$	$10^{14}\text{–}10^{15}$	$>10^{14}$	$>10^{14}$
212 F	1.2×10^{8} [b]	—	$0.21\text{–}>100 \times 10^{13}$	2.0×10^{13}
570 F	5.0×10^{6}	—	$0.6\text{–}800 \times 10^{8}$	5.5×10^{11}
930 F	4.0×10^{5} [c]	—	$0.32\text{–}300 \times 10^{6}$	5.5×10^{8}
1290 F	—	10^{6}	$2.3\text{–}500 \times 10^{5}$	1.4×10^{7}
1650 F	—	—	$7.0\text{–}680 \times 10^{3}$	8.2×10^{5}
Dielectric Strength, v/mil	55–300	300	145–280	60–290
Dielectric Constant				
60 Cycles	5.4–7.0	—	5.9–6.3	9.1
1 Mc	—	6.5–7.0	5.5–6.51	5.30–9.20
100 Mc	—	—	5.6–6.0	8.6
10,000 Mc	—	—	5.3–5.8	8.4
Dissipation Factor				
60 Cycles	0.0090–0.0112	—	0.0013–0.0150	0.0360
1 Mc	—	—	0.0011–0.0075	0.0007–0.0022
100 Mc	—	—	0.0009–0.0028	0.0012
10,000 Mc	—	—	0.0014–0.0054	0.0027
Loss Factor				
60 Cycles	0.053–0.060	—	0.008–0.090	0.327
1 Mc	—	—	0.007–0.0252	0.0041–0.0135
100 Mc	—	—	0.005–0.016	0.010
10,000 Mc	—	—	0.008–0.030	0.023
T_e Value, F°	680–842	1292–1472	824–1544	1292–1598
Temp Coef of Capacitance Chg [a]	630	—	120	175
HEAT RESISTANCE				
Max Rec Svc Temp, F	1820	3000–3200	1832	2012
USES	Low voltage insulators, vitrified high voltage insulators, wire supports, outlet boxes, lightning arrestors, suspension insulators, x-ray rods and tubes	High temperature insulators, spark plugs, laboratory ware	Aircraft insulators, appliance housings, electric line insulators, tube sockets, electrical instrument spacers and feedthrough bushings, fuel igniters, camera and projector rollers, thermostat controls	Aircraft firewall connector plugs and glow plugs, electronic tube sockets, coil forms, spacers, brackets, printed circuits and plates, pump valves, plungers and seats

[a] 77–185 F, parts per million. [b] 392 F. [c] 752 F.

Mica—Sheet, Molded

Type →	Natural Muscovite	Synthetic Fluor-Phlegopite	Glass-Bonded Synthetic[a]	
			Insulation	Capacitor
PHYSICAL PROPERTIES				
Specific Gravity	2.6–3.2	2.9	3.0, 2.6–3.8	3.25, 3.5–3.8
Ther Cond, Btu/hr/sq ft/°F/ft	0.25–0.36	0.3–0.4	0.29, 0.23–0.31	—
Coef of Ther Exp, per °F	1.8×10^{-6}	$1.44\text{–}2.70 \times 10^{-6}$	$0.58\text{–}0.62 \times 10^{-6}$	$1.8, 1.8\text{–}2.0 \times 10^{-6}$
Spec Ht, Btu/lb/°F	0.20	0.25	0.16, 0.13–0.24	—
Water Absorption	Low	Low	Nil	Nil
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	$20\text{–}30 \times 10^6$	25×10^6	$9\text{–}12, 7\text{–}8 \times 10^6$	$9\text{–}12, 7\text{–}8 \times 10^6$
Ten Str, 1000 psi	40–50	45–55	6–7, 5–6	6, 5
Hardness				
Knoop	90	200	M110–120,[b] M115–130[b]	—
Mohs	3–4	3.4	—	—
Impact Str (Izod notched), ft-lb/in.	—	—	1.8, 0.7	—
Flex Str, 1000 psi	—	—	15–18, 10–15	12–15, 10–15
Compr Str, 1000 psi	>150	>150	35–42, 20–25	35–42, 20–25
ELECTRICAL PROPERTIES				
Vol Res, ohm-cm	$10^{13}\text{–}10^{17}$	$10^{13}\text{–}10^{17}$	$10^{14}\text{–}10^{16}, 10^{14}\text{–}10^{17}$	$10^{14}, 10^{14}$
Dielec Str (step by step, ⅛ in.), v/mil	1000–2000	1000–2000	400–600[c], 400–500[c]	270–400, 300–400
Dielec Const				
60 Cycles	5.4–8.7	6.5	7.5–7.6, 7.0–9.5	—
10^6 Cycles	5.4–8.7	6.5	7.4–7.9, 6.9–9.2	10–25, 10–40
Dissip Factor				
60 Cycles	0.0025	0.002–0.004	0.0035–0.0070, 0.007–0.050	0.0020–0.0040, 0.0025
10^6 Cycles	0.0001–0.0004	0.0001–0.0003	0.0015–0.0020, 0.0015–0.0120	0.0035
Arc Resistance, sec	High	High	300, 250	300, 250
FABRICATING PROPERTIES				
Machinability	Fair, readily punched	Fair, punches more readily than Natural	Fair to good; poor	Fair to good; poor
Moldability	—	—	Fair; good[c]	Fair; good
HEAT RESISTANCE				
Max Rec Svc Temp, F	1110	1400–1800	600–1000[c], 500–800[c]	600–700, 500–600
Heat Dist Temp (264 psi), F	—	—	850[c], 700[c]	800, 650
Ther Shock Res	—	—	Moderate	Moderate
CHEMICAL RESISTANCE	Good res to most chemicals and molten materials exc hydrofluoric acid. Oils generally cause delamination	Slightly better chemical res than Natural; high res to oils. High res to high pressure, high temp water	Good res to organic solvents; poor res to strong acids and alkalis	Good res to organic solvents; fair res to strong acids and alkalis
USES	Furnace peepholes, boiler gage glass; capacitors, tube spacers	Experimental high temp tube spacers and waveguide windows; used to make glass-bonded synthetic mica	Electromechanical devices, high temp (660–900 F) insulators requiring high stability (e.g., computer parts)	Stable capacitors, tuners; high temp uses

[a] The first value or range in each column refers to glass-bonded mica produced by compression molding, the second to transfer molding.
[b] Rockwell.
[c] A new modified type, called "ceramoplastic," has a dielectric strength of 270 v/mil for ⅛-in. thickness; excellent moldability; max svc temp of 1200 F; and heat dist temp of 1100 F. Another machinable grade has a max svc temp of 1550 F.

Refractory Ceramics and Cermets—Fired or Sintered Parts

HIGH ALUMINA CERAMICS[a]

Type (% alumina) ➡	85%	95%	99+%
PHYSICAL PROPERTIES			
Specific Gravity	3.45	3.65	3.85
Ther Cond (200 F), Btu/hr/sq ft/°F/ft	6.2	10.3	10.7
Coef of Ther Exp, per °F			
77–390 F	3.1×10^{-6}	3.7×10^{-6}	—
77–750 F	3.7×10^{-6}	4.0×10^{-6}	—
77–1100 F	3.9×10^{-6}	4.3×10^{-6}	4.3×10^{-6}
77–1470 F	4.1×10^{-6}	4.5×10^{-6}	—
77–1830 F	4.3×10^{-6}	4.7×10^{-6}	—
Water Absorption, %	0.0	0.0	0.0
Max Rec Svc Temp, F	2460	3000	3540
ELECTRICAL PROPERTIES			
Dielec Str, v/mil	200	250	300
Dielec Const (77 F, 1 mc)	8.2	8.9	9.6
Power actor (77 F, 1 mc)	0.0009	0.00035	0.00027
Loss Factor (77 F, 1 mc)	0.007	0.003	0.003
Te Value, F	1560	1960	2012
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	32×10^{6}	40×10^{6}	50×10^{6}
Ten Str, 1000 psi	20	30	39
Flex Str, 1000 psi	41	45	47
Compr Str, 1000 psi	250	300	400
Hardness			
Mohs	9	9	9
Knoop	1450	1750	—
Impact Str (Charpy), in.-lb	6.5	7.0	—

[a] The values given are not maximum values and are dependent upon the minor components or fluxes used as well as a number of other factors

ALUMINA CERMETS

Type ➡	Chromium-Alumina	Molybdenum-Chromium-Alumina[a]
PHYSICAL PROPERTIES		
Density, lb/cu in.	0.21	0.22
Porosity, %	<0.25	<0.25
Melting Point (approx), F	3362	—
Ther Cond, Btu/hr/sq ft/°F/ft	29[a]	—
Coef of Ther Exp, per °F	4.7×10^{-6} [b]	5.2×10^{-6} [c]
Spec Ht (calc), Btu/lb/°F	0.16	0.14
Poisson's Ratio	0.22	0.25–0.27
MECHANICAL PROPERTIES		
Mod of Elast in Tension, 10^6 psi	41×10^{6}	$37–39 \times 10^{6}$
Ult Ten Str, 1000 psi		
Rm Temp	21	—
800 F	20.5	—
1200 F	20	—
1500 F	19.7	—
1800 F	16.8	—
2000 F	11.7	—
Hardness (Rockwell)	C37	C45–55
Mod of Rupture, 1000 psi		
Rm Temp	45	55[d]
1800 F	27	55
2100 F	18	29
2400 F	4.6	12
Compr Str, 1000 psi	110	240
Mod of Rigidity, psi	17×10^{6}	15×10^{6}
Shear Str, 1000 psi	40	—
Bulk Modulus, psi	21×10^{6}	26×10^{6}

[a] At 500 F. [b] At 32–1832 F. [c] At 68–1472 F.
[d] Addition of tungsten raises room temperature modulus of rupture to about 70,000 psi.

REFRACTORY OXIDES

Type ➡	Beryllia (BeO)	Calcia (CaO)	Magnesia (MgO)	Thoria (ThO_2)	Zirconia (stabilized ZrO_2)	Silica (vitreous SiO_2)
Melting Point, F	4620	4710	5070	6000	4710	—
Ther Cond (at spec temp and porosity), Btu/hr/sq ft/°F/ft	9.52 (2190 F, 5–10%)	4.12 (1830 F, 9%)	1.47 (2190 F, 22%)	0.0 (2190 F, 17%)	0.53 (2190 F, 28%)	0.80 (0.9%)
Coef of Ther Exp, per °F	52.8×10^{-7} (68–2550 F)	75.5×10^{-7} (68–2190 F)	77.8×10^{-7} (68–2550 F)	52.8×10^{-7} (68–2550 F)	30.6×10^{-7} [a] (68–2190 F)	2.8×10^{-7} (68–2280 F)
Max Use Temp in Oxidizing Atm, F	4350	4350	4350	4890	4530	—
Hardness (Mohs)	9	4.5	6	7	7–8	—
Thermal Shock Resistance	Excellent	Fair	Fair	Poor	Fair	Excellent
Stability in —						
Reducing Atmosphere	Excellent	Poor	Poor	Good	Good	Fair
Carbon	Excellent	Poor	Good	Fair	Fair	Good
Acid Slags	—	Poor	Poor	Poor	Good	Good
Basic Slags	Fair	Fair	Good	Good	Poor	—
Metals	Good	Fair	Fair	Excellent	Good	—

[a] Depends on degree of stabilisation.

continued on next page

Refractory Ceramics and Cermets—Fired or Sintered Parts

CARBIDES

Type →	Silicon Carbide			Boron Carbide
	Silicate-Bonded	Silicon Nitride-Bonded	Densified	
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.093	0.104	0.112	0.087[a]
Porosity, %	9–17	6–10	Negligible	Negligible
Ther Cond (2200 F), Btu/hr/sq ft/°F/ft	9	10	25[b]	16
Coef of Ther Exp (0–2550 F), per °F	2.4 x 10^{-6}	2.4 x 10^{-6}	2.17 x 10^{-6}	1.73 x 10^{-6}
Specific Heat (0–2550 F), Btu/lb/°F[a]	0.285	0.288	0.331	—
Max Service Temperature, F				
Inert Atmosphere	3200	3200	4000	4100
Oxidizing Atmosphere	2900	3000	3000	1000
MECHANICAL PROPERTIES				
Mod of Elast in Tension (77 F), psi	13.2 x 10^6	17 x 10^6	68 x 10^6	42 x 10^6
Tensile Strength (77 F), 1000 psi	Very low	3	25	22.5
Compressive Strength (77 F), 1000 psi	15	20	150	420
Modulus of Rupture (77 F), 1000 psi	2.2	5.5	24	50

[a] Boron carbide is available in densities ranging from 0.069 to 0.091 lb per cu in. [b] 1832 F.

CARBIDE-BASE CERMETS

Type (base) →	Titanium Carbide (TiC)[a]	Tungsten-Titanium Carbide ($WTiC_2$)[b]	Tungsten Carbide (WC)	Chromium Carbide (Cr_4C, Cr_7C_3, Cr_3C_2)[c]
Density, lb/cu in.	0.20–0.26	0.38–0.47	0.47–0.55	0.25–0.29
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	—	16.5–32.9	25.7–50.1	—
Coef of Ther Exp (68–1200 F), per °F	4.3–7.5 x 10^{-6}	3.5–4.0 x 10^{-6}	2.5–3.9 x 10^{-6}	5.8–6.3 x 10^{-6}[f]
Electrical Conductivity, % IACS	1.34–6.0	4.3–5.8	5.0–10.1	2.58–2.78
Mod of Elast in Tension, psi				
70 F	42–57 x 10^6	65.5–80.6 x 10^6	61.6–94.3 x 10^6	—
1600–1800 F	33–48 x 10^6	—	—	—
Tensile Strength, 1000 psi[d]				
75 F	26–134 (0–61)	118–145	130[e]	36–37 (0)
1500 F	45–94 (0–2.7)	—	—	20–42 (0.2)
1800 F	35–72 (0–2.4)	—	—	—
Hardness (Rockwell)	A73–A91	A90–A93	A85–A93	A86.5–A89
Impact Strength (unnotched Charpy), ft-lb				
75 F	1.5–16	5.3–8.9	—	—
1800 F	2.5–16	—	—	—
Transverse Rupture Strength, 1000 psi	122–236	125–350	175–460	100–120
Stress-Rupture Strength (100 hr, 1800 F), 1000 psi	8–28	—	—	—
Compressive Strength, 1000 psi	265–450	585–705	518–800	422–480

[a] Property range covers grades ranging from 17.5% to 90% TiC with different binder metal contents.
[b] Property range covers various grades of different carbide-metal proportions.
[c] The type of chromium carbide and the type of binder metal affects properties.
[d] Elongation (%) in parenthesis. [e] Typical of one grade. [f] 68–576 F.

Refractory Ceramics and Cermets—Fired or Sintered Parts

OTHER CARBIDES

Type ➡	Beryllium Carbide (Be_2C)	Titanium Carbide (TiC)	Columbium Carbide (CbC)	Tantalum Carbide (TaC)	Zirconium Carbide (ZrC)
Ther Cond (68–795 F), Btu/hr/sq ft/°F/ft	12.1	9.9[a]	8.23[a]	12.8[a]	11.9[a]
Coef of Ther Exp (77–1472 F), per °F	5.8×10^{-6}	4.1×10^{-6}	—	4.6×10^{-6}	3.7×10^{-6}
Electrical Resistivity, ohm-cm[a]	1.1	1.05×10^{-4}	7.4×10^{-5}	2×10^{-6}	6.34×10^{-5}
Hardness (Mohs')	9+	8–9	9–10	9+	8–9
Compressive Strength, 1000 psi[a]	105	109	—	—	238
Mod of Rupture, 1000 psi[a]	16	—	—	—	—
Ther Shock Res (air quenched), cycles at designated temp range (F)	4 at 2000–1470	—	—	—	—
Fabrication Methods	Hot pressing, steel die pressing and sintering, hydrostatic pressing and sintering	Hot pressing, steel die pressing and sintering	Hot pressing, steel die pressing and sintering	Hot pressing, steel die pressing and sintering	Hot pressing, steel die pressing and sintering

[a] Room temperature.

MOLYBDENUM DISILICIDE ($MoSi_2$)

Type ➡	Cold Pressed, Sintered	Hot Pressed
PHYSICAL PROPERTIES		
Density, lb/cu in.	0.216	0.224
Melting Point, F	3685 ±90	3685 ±90
Electrical Resistivity, microhm-cm		
77 F	—	21.5–27.2
2900 F	—	75–80
Coef of Ther Exp (78–2700 F), per °F	—	5.1×10^{-6}
MECHANICAL PROPERTIES		
Tensile Strength, 1000 psi		
1800 F	—	40
2000 F	—	42
2200 F	—	43
2400 F	—	41
Hardness		
Rockwell	C57[a]	A80–87[b]
Knoop (1 kg)	1065	850–870
Compressive Strength, 1000 psi	100[c]	350
Modulus of Rupture, 1000 psi		
77 F	51	36–57
1800 F	51–67	—
2000 F	51–86	72
2200 F	[d]	55
Stress-Rupture Strength (100 hr), 1000 psi		
1600 F	—	35
1800 F	—	29
1900 F	—	13.5
2000 F	—	8.5

[a] Superficial hardness.
[b] Some indentation cracking.
[c] Cast specimens.
[d] Test not applicable because bars showed too much plasticity.

NITRIDES

Type ➡	Boron Nitride	Silicon Nitride[a]
PHYSICAL PROPERTIES		
Density, lb/cu in.		
Theoretical	0.081	0.124
Actual	0.076	0.111
Melting Point, F	>3000[b]	3452[c]
Ther Cond, Btu/hr/sq ft/°F/ft	16.6, 15.4[d]	0.90[e]
Coef of Ther Exp (70–1800 F), per °F	4.3	1.37
MECHANICAL PROPERTIES		
Mod of Elast in Tension, 10^6 psi		
75 F	12.4×10^6	—
1300 F	1.5×10^6	—
Hardness		
Mohs	2	—
Rockwell	—	A99
Modulus of Rupture, 1000 psi		
75 F	15.9	10
1300 F	3.8	—
ELECTRICAL PROPERTIES		Not applicable
Volume Resistivity, ohm-cm		
75 F	1.7×10^{13}	
900 F	2.3×10^{10}	
1800 F	3.1×10^4	
Dielectric Constant (10^2–10^8 cps)	4.15	
Dissipation Factor		
10^2 Cycles	0.00103	
10^6 Cycles	0.00020	
10^{10} Cycles	0.0003	

[a] Mechanical properties are given for direction parallel to direction of forming pressure. Values perpendicular to this direction may be one-half to one-quarter of these values.
[b] May be used continuously at 3000 F, and higher under special conditions.
[c] Sublimes.
[d] Values at 570 F and 1800 F, respectively.
[e] 400–2400 F.

Glass (Industrial)—Flat, Pressed, Blown

Type →	Fused Silica	96% Silica	Soda-Lime Glasses		Alumina-Silicate
			Plate	General Purpose	
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.079	0.078	0.09	0.089	0.091
Softening Point, F	3050	2800	1330	1285	1675
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	0.80	0.80	0.53	0.53	—
Coef of Ther Exp (32-570 F), per °F	0.30×10^{-6}	0.45×10^{-6}	4.8×10^{-6}	5.1×10^{-6}	2.3×10^{-6}
Spec Ht, Btu/lb/°F	0.185	0.178	0.20	0.20	0.180
Elec Res (212 F), ohm-cm	$>10^{15}$	$>10^{15}$	—	4×10^{9}	$>10^{15}$
Power Factor (68 F, 1 mc), %	0.001	0.02-0.04	0.80	0.90	0.16
Dielec Const (68 F, 1 mc)	3.8	3.8	7.4	7.2	6.3
Ther Stress Res, °F[a]	—	390	—	65	85
Ther Shock Res, °F[b]	Very high	Very high	135	125	240
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	10.2×10^{6}	9.7×10^{6}	$9\text{-}10 \times 10^{6}$	$9\text{-}10 \times 10^{6}$	12.7×10^{6}
Normal Work Stress (annealed), psi	1000	1000	1000	1000	1000
Max Rec Svc Temp, F					
Annealed	1650	1500	900	840	1200
Tempered	—	—	550	480	840
THERMAL TREATMENT					
Annealing Temp (stress relief), F	2080	1670	1010	950	1315
FABRICATING PROPERTIES					
Workability	Glass can be ground or polished without great difficulty. Machining limited to sawing or drilling. Sawing readily accomplished with an impregnated wheel. Drilling is difficult, but is done with special carbide-tipped drills using kerosene as a lubricant				
Joining	Glass can be joined by heat sealing using a blast lamp, a gas torch or electric heating. Parts must have closely similar coefficients of expansion; otherwise, intermediate pieces having intermediate coefficients must be used. Glass-to-metal seals are also made by this latter process				
CHEMICAL RESISTANCE	Glass is attacked by hydrofluoric acid, hot concentrated phosphoric acid and strong alkalis. It is resistant to most other chemicals				
USES	Ultraviolet energy transmission, chemical apparatus, thermocouple protection tubes, laboratory apparatus	Ultraviolet energy transmission, chemical reaction vessels, thermocouple protection tubes, laboratory apparatus	Sheet and plate glass, molded glassware, bulbs for electric lamps, bottles, vials, fluorescent lamp tubing		

[a] Measured by subjecting the two sides of a tube or constrained plate to a temperature differential. Index is the differential that causes a stress of 1000 psi on cooler surface.
[b] Measured by heating squares of annealed glass, 6 by 6 by ¼ in., to a uniform temperature and dropping into cold water. Index is maximum temperature differential at which no breakage occurs.

Glass (Industrial)—Flat, Pressed, Blown

Type →	Borosilicate Glasses			Lead Silicate Glasses	
	Low Expansion Chemical Resistant	Baking and Kovar Sealing	Low Electrical Loss	Lamp Tubing	High Lead
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.080	0.081–0.082	0.077	0.110	0.154
Softening Point, F	1500	1300–1425	—	1160	1075
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	0.67	—	0.67	0.50	0.45
Coef of Ther Exp (32–570 F), per °F	1.85×10^{-6}	$2.0–2.5 \times 10^{-6}$	$1. \times 10^{-6}$	5.0×10^{-6}	5.1×10^{-6}
Spec Ht, Btu/lb/F	0.195	0.195	—	0.17	0.16
Elec Res (212 F), ohm-cm	10^{12}	3×10^{13}	$>10^{16}$	10^{14}	$>10^{16}$
Power Factor (68 F, 1 mc), %	0.46	0.26–0.28	0.06	0.16	0.09
Dielec Const (68 F, 1 mc)	4.6	4.7–5.1	4.0	6.6	9.5
Ther Stress Res, °F[a]	—	—	—	65	—
Ther Shock Res, °F[b]	320	—	—	120	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	9.8×10^6	—	6.8×10^6	9.0×10^6	7.6×10^6
Normal Work Stress (annealed), psi	1000	1000	1000	1000	1000
Max Rec Svc Temp, F					
Annealed	900	800–840	810	720	720
Tempered	550	420–500	450	380	360
THERMAL TREATMENT					
Annealing Temp (stress relief), F	1020	890–975	910	800	800
FABRICATING PROPERTIES					
Workability	Glass can be ground or polished without great difficulty. Machining limited to sawing or drilling. Sawing readily accomplished with an impregnated wheel. Drilling is difficult, but is done with special carbide-tipped drills using kerosene as a lubricant				
Joining	Glass can be joined by heat sealing using a blast lamp, a gas torch or electric heating. Parts must have closely similar coefficients of expansion; otherwise, intermediate pieces having intermediate coefficients must be used. Glass-to-metal seals are also made by this latter process				
CHEMICAL RESISTANCE	Glass is attacked by hydrofluoric acid, hot concentrated phosphoric acid and strong alkalis. It is resistant to most other chemicals				
USES	Heat exchanger tubes, chemical apparatus, cooking ware, electrical insulators, sight and gage glasses, containers for chemicals and medicines, metal sealing, industrial piping, industrial glassware requiring thermal resistance, special lighting ware, heat resisting lenses			Lamp tubing, electrical and electronic applications, thermometer tubing, metal sealing	Electrical capacitors, x-ray shielding

[a] Measured by subjecting the two sides of tube or constrained plate to a temperature differential. Index is the differential that causes a stress of 1000 psi on cooler surface.
[b] Measured by heating squares of annealed glass, 6 by 6 by ¼ in., to a uniform temperature and dropping into cold water. Index is maximum temperature differential at which no breakage occurs.

Carbon and Graphite—Molded, Extruded

Material →	Carbon (Petroleum coke base)	Graphite
PHYSICAL PROPERTIES		
Density, lb/cu ft	93.3–102.0	90–116
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	3–5	70–120
Coef of Ther Exp (70–212 F), per °F	$1.3\text{–}1.5 \times 10^{-6}$	$1.0\text{–}1.3 \times 10^{-6}$
Specific Heat (100 F), Btu/lb/°F	0.18	0.18
MECHANICAL PROPERTIES[d]		
Mod of Elast in Tension, psi	$1.6\text{–}2.3 \times 10^{6}$	$0.5\text{–}1.8 \times 10^{6}$
Tensile Strength, psi	900–1100	440–2000
Compressive Strength, psi	6300–9000	1800–8500
Flexural Strength, psi	2500–3000	800–3300
Hardness (scleroscope)	30–50	8–45
ELECTRICAL PROPERTIES		
Electrical Resistivity (68 F), microhm-cm	3500–4600	800–1300
Contact Resistance, ohms/sq in.		
Against Carbon	0.0058, 0.0026, 0.0017[a]	—
Against Copper	0.0133, 0.0093, 0.0042[a]	0.000704, 0.000315, 0.000162, 0.0000555[b]
Against Brass	0.038, 0.012, 0.0052[a]	0.00092, 0.000214, 0.000109[c]
Against Aluminum	0.138, 0.078, 0.015[a]	0.0448, 0.0067, 0.0020[c]
Against Graphite	—	0.000473, 0.000175, 0.000064, 0.000031[b]
Against Steel	—	0.01309, 0.00438, 0.00177, 0.000737[b]
FABRICATING PROPERTIES	Powdered material mixed with binder and shaped by molding or extrusion, then baked at approx 1800 F for carbon, 4500 F for graphite	
CHEMICAL RESISTANCE	Carbon begins to oxidize in air at approximately 630 F and graphite at approximately 810 F, although the rate of oxidation is not rapid even at high temperatures. With a steam or a carbon dioxide atmosphere, temperature can be raised above a red heat before excessive oxidation occurs. Alkalis in solution do not attack these materials but fused hydroxides and carbonates attack them at high temperatures. They are not attacked by dilute acids, including hydrofluoric, but strongly oxidizing chemicals will attack them	
USES[e]	Mechanical: sealing rings, pump and valve parts, bearings, pistons, and piston rings. Electrical: battery carbons, contacts, welding carbons, anodes, brushes for electrical machines. Refractory: linings, molds, continuous casting dies, furnace boats, brazing jigs. Chemical: pipe, pumps, fittings, heat exchangers, valves, towers and accessories, porous filtering media. Nuclear: neutron moderator, reflector, structural, fuel element matrix	

[a] Pressures of 5, 25 and 75 psi, respectively.
[b] Pressures of 25, 150, 400 and 1000 psi, respectively.
[c] Pressures of 25, 150 and 400 psi, respectively.
[d] Strength of graphite generally increases with increasing temp.
[e] There are now available 1) special carbon-graphite mixtures for mechanical applications (especially seal rings) and 2) flexible graphitized industrial textiles for a variety of applications requiring the properties of graphite plus flexibility.

Natural Fibers

Type →	Cotton	Bast				Hard			Animal		
		Flax	Jute	Hemp	Ramie	Manila (abaca)	Sisal	Henne-quin	Wool	Horse-hair	Silk
NATURE OF FIBER											
Length, in.	½–2½	6–40	10–60	40–80	15–25	20–40	24	20	1½–15	1–25	Filament
Width, μ	17	16	17	20	47	19	19	20	28	100	11
Cross Section	Flat tube	Tube	Bunched cells	—	Flat tube	Bunched cells	Bunched cells	Bunched cells	Round	Round	Round
PHYSICAL AND MECHANICAL PROPERTIES											
Specific Gravity	1.55	1.50	1.48	1.48	1.55	—	—	—	1.30	1.30	1.25–1.35
Breaking Tenacity, gm/den											
70 F, 65% RH	3.0–4.9	6.3	3.0–5.9	5.9–6.9	6.5	6.0–7.5	4.1	3.0–3.5	1.0–1.7	—	2.8–5.2
Wet	3.3–6.37	—	—	—	—	6.0–8.5	—	2.5–3.0	0.76–1.63	—	2.1–4.9
Ten Str (70 F, 65% RH), 1000 psi	44–109	115	57–112	112–132	130	125	100–120	—	20–29	—	45–83
Breaking Elongation, %											
70 F, 65% RH	3–7	3	—	2–6	3–6	2–3	2–2.5	—	25–35	—	13–31
Wet	—	—	—	—	—	—	—	—	25–50	—	—
Stiffness (avg), gm/den[a]	57–60	270	185	200	167	175	127	—	3.9	—	18
Strain Recovery (at 2%), %[b]	74, 45 (5%)	65	74 (1%)	—	52	—	—	—	99, 63 (20%)	99, 63 (20%)	92
Toughness (avg), gm-cm/den-cm	0.15	0.09	0.03	—	—	—	—	—	0.25	—	0.44
Moisture Regain (70 F, 65% RH), %	7	12	13.75	11.75	12	—	—	—	16	—	11
RESISTANCE TO ENVIRONMENTS											
Acids											
Strong	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Good[d]	—	Poor
Weak	Poor (hot)	Poor	—	Poor	—	—	—	—	Good	—	Fair
Alkalis											
Strong	Exc	Good	Good	Good	Good	Good	Good	Good	Poor	Poor	Poor
Weak	Exc	Good	Good	Good	Good	Good	Good	Good	Attacked	Poor	Poor (hot)
Other Chemicals	Show generally good resistance to organic solvents; cotton bleached by hyperchlorites and peroxides; swells and disintegrates in cuprammonium hydroxide								Bleached by perox-ides or SO_2	Resistant	Resistant
Heat	Good to 275 F	Good to 275 F	—	Good to 275 F	Good to 275 F	—	—	—	Good to 212 F	—	Disinte-grates at 340 F
Sunlight (prolonged exposure)	Weak-ened	None	None	None	None	None	None	None	Weak-ened	Weak-ened	Weak-ened
Microorganisms	Poor	Very good	Good	Good	Exc	Good	Poor	Poor	Fair	Fair	Good
Flame[c]	Burns	Burns	Burns	Burns	Burns	Burns	Burns	Burns	Slow burn	Slow burn	Burns

[a] Ratio of breaking stress to breaking strain (i.e., gm/den to rupture divided by strain in cm/gage cm at breaking stress).
[b] Recovery after 2% strain, except where specific percentage strain is given in parentheses.
[c] Basic flammability of untreated fiber.
[d] Except hot H_2SO_4.

Synthetic Fibers

Type ➜	Regenerated Cellulose (rayons)				Cellulose Esters		Fluorocarbon
	Viscose		Saponified Acetate				
	Regular to Medium Tenacity	High Tenacity	Fortisan	Fortisan 36	Cellulose Acetate	Cellulose Triacetate (Arnel)	TFE (Teflon)
NATURE OF FIBER							
Length, in.	Staple, filament	Filament	Filament		Staple, filament	Staple, filament	Filament
Width, μ	8.4–4.3	10–15	3-9		11–46	—	—
Cross Section	Irregular	Irregular	Irregular		Clover leaf	Clover leaf	Circular
PHYSICAL AND MECHANICAL PROPERTIES							
Specific Gravity	1.46-1.52	—	1.5	1.5	1.32	1.3	2.3
Breaking Tenacity, gm/den 70 F, 65% RH	1.5–3.2	3.0–5.0	6–7	8	1.3–1.5	1.2–1.4	1.6
Wet	0.7–1.9	1.9–3.6	5.1–6.0	6.0–6.4	0.8–1.2	0.8–1.0	1.6
Ten Str (70 F, 65% RH), 1000 psi	29–65	65–105	136	155	22–28	20–26	47
Breaking Elongation, % 70 F, 65% RH	15–30	9–22	6	6.2	23–34	22–28[d]	13
Wet	17–40	14–30	6	6	30–45	30–40	13
Stiffness (avg), gm/den[a]	11.1–16.6	25.5–29	117	135	5.5	5.2	12
Strain Recovery (at 2%), %[b]	30–97	70–100	100 (20%), 60 (40%)	85, 70 (5%)	48–65 (4%)	88 (3%), 43 (10%)	—
Toughness (avg), gm-cm/den-cm	0.19–0.21	0.22–0.30	0.21	0.26	0.17	0.16	0.12
Moisture Regain (70 F, 65% RH), %	13	13	10.7	9.6	6	3.2	None
RESISTANCE TO ENVIRONMENTS							
Acids							
Strong	Similar to cottons, i.e., disintegrated by hot dilute or cold concentrated acids		Similar to cotton		Decomposed	Similar to acetate	Inert
Weak					Good		
Alkalis							
Strong	Swell; strength reduced				Saponifies	Saponifies	Inert
Weak	Good				Res (cold)	Res (cold)	Inert
Other Chemicals	Attacked by strong oxidizing agents; not damaged by hypochlorite or peroxide bleaches				Similar to viscose	Similar to viscose	Only affected by alkali metals and some hot, pressurized halogenated hyd.
Heat	Lose strength at 300 F. Decompose at 350–400 F				Sticky at 350–375 F; softens at 400–475 F; melts at 500 F	When heat treated will not stick at 480 F; melts at 575 F	Nondegraded at 400 F; extremely slow sublimation at 550 F
Sunlight (prolonged exposure)	Weakened		Resistant		Weakened	Weakened	Inert
Microorganisms	Attacked		Attacked		Resistant	Resistant	Inert
Flame[c]	Highly flammable		Burns		Burns slowly	Burns slowly	Self-exting

[a] Ratio of breaking stress to breaking strain (i.e., gm/den to rupture divided by strain in cm/gage cm at breaking stress).
[b] Recovery after 2% strain except where specific percentage strain is given in parentheses.
[c] Basic flammability of untreated fiber. [d] For filament; 35–40% for staple.

Synthetic Fibers

Type ⇒	Acrylics						
	Poly-acrylonitrile (Orlon)	**Acrylonitrile-Vinyl Derivatives** (Acrilan)	**Acrylonitrile-Vinyl Chloride** (Dynel)	**Modified Acrylic** (Verel)	**Acrylonitrile-Base** (Creslan)	**Dinitrile** [a] (Darvan)	**Nitrile** [b] **Alloy** (Zefran)
NATURE OF FIBER							
Length, in	Staple	Staple	Staple	Staple	—	—	—
Width, μ	14–27	15–30	—	—	—	—	—
Cross Section	Dogbone	—	—	—	—	—	—
PHYSICAL AND MECHANICAL PROPERTIES							
Specific Gravity	1.14	1.17	1.3	1.37	1.17	1.18	1.19
Breaking Tenacity, gm/den 70 F, 65% RH	2.2–2.6	2.5	2.5–3.3	2.5–2.8	3.3	1.75	3.5
Wet	1.8–2.1	2.0	2.5–3.3	2.4–2.7	3.3	1.5	3.1
Ten Str (70 F, 65% RH), 1000 psi	32–39	37–40	40–57	42–47	41	26	53
Breaking Elongation, % 70 F, 65% RH	20–28	36	30–42	33–35	32	30	33
Wet	26–34	44	30–42	32–34	32	30	33
Stiffness (avg), gm/den [c]	10	7	8.2	8.0	10.3	6	11
Strain Recovery (at 2%), % [d]	—	99, 89 (5%)	94	88 (4%), 55 (10%)	90 (1%), 48 (5%)	100 (3%), 75 (5%)	99, 72 (10%)
Toughness (avg), gm-cm/den-cm	0.40	0.46	0.53	0.46	0.53	0.3	0.58
Moisture Regain (70 F, 65% RH), %	1.5	1.2	0.3–0.4	3.5–4	1.3	2–3	2.5
RESISTANCE TO ENVIRONMENTS							
Acids							
Strong	Good–exc	Good–exc	Good	Exc	Good–exc	Good–exc	Exc
Weak	Exc	Exc	Exc	Exc	Exc	Exc	Exc
Alkalis							
Strong	Poor	Poor	Good	Discolors some, no weakening	Poor	Poor	Fair
Weak	Fair–good	Fair–good	Exc		Fair–good	Fair–good	Good
Other Chemicals	Not harmed by solvents, oils, greases and some acid salts	Similar to Orlon	Good; softened by acetone and some ketones	Good; dissolves in warm acetones	Good	Good	Good
Heat	No weakening after 32 days at 257 F; sticking temp 455 F [f]	5% shrinkage at 487 F	Unless heat treated, shrinks at 250 F	Exposure over 300 F causes stiffening	Sticking temp 450 F [f]	Unaffected by 195 days at 300 F; sticking temp 340 F [f]	Sticking temp 490 F [f]
Sunlight (prolonged exposure)	Very resistant	Resistant	Weakened	—	—	Resistant	Resistant
Microorganisms	Resistant	Resistant	Resistant	—	—	Resistant	Resistant
Flame [e]	Burns slowly	Burns slowly	Self-exting	Self-exting	Burns	Burns	Burns

[a] Though not an acrylic (actually a polymer of vinylidene cyanide), it is grouped here because of similarities of properties.
[b] Nitrile "alloy" based on acrylonitrile.
[c] Ratio of breaking stress to breaking strain (i.e., gm/den to rupture divided by strain in cm/gage cm at breaking stress).
[d] Recovery after 2% strain, except where specific percentage strain is given in parentheses.
[e] Basic flammability of untreated fiber.
[f] Copper block method.

continued on next page

Synthetic Fibers

Type →	Polyamides						Polyesters		
	Nylon 66			Nylon 6			Polyethylene Terephthalate (Dacron)		
	Regular	High Tenacity	Staple	Regular	High Tenacity	Staple	Regular	High Tenacity	Staple
NATURE OF FIBER									
Length, in.	Filament		Staple	Filament		Staple	Filament		Staple
Width, μ	11–43	16–43	14–43	—		—	11–28		18–25
Cross Section	Round	Round	Round	Round		Round	Circular		—
PHYSICAL AND MECHANICAL PROPERTIES									
Specific Gravity	1.14	1.14	1.14	1.14	1.14	1.14	1.38	1.38	1.38
Breaking Tenacity, gm/den									
70 F, 65% RH	4.6–5.9	5.9–8.8	4.0–4.7	4.5–5.8	6.8–8.6	3.8–5.5	4.4–5.0	6–7	3.8–4.3
Wet	4.0–5.2	5.1–7.6	3.5–4.2	4.3–5.3	5.4–7.5	—	4.4–5.0	6–7	3.8–4.3
Ten Str (70 F, 65% RH), 1000 psi	67–86	86–128	58–69	73–84	109–125	70–80	77–88	106–123	67–76
Breaking Elongation, %									
70 F, 65% RH	26–32	18–28	38–42	24–34	16–17.5	37–40	19–25	9–11	30–36
Wet	30–37	21–32	42–46	28–38	19–24	42–46	19–25	9–11	30–36
Stiffness (avg), gm/den[a]	18	32	10	23	48	17–20	21	65	12
Strain Recovery (at 2%), %[b]	100, 100 (8%)	100 (4%)	—	100, 100 (8%)	100 (4%)	100	97, 80 (8%)	100, 90 (8%)	—
Toughness (avg), gm-cm/den-cm	0.76	0.85	0.87	0.67	0.75	0.64–0.78	0.78	0.50	1.03
Moisture Regain (70 F, 65% RH), %	4.5	4.5	4.5	4.0	4.0	4.0	0.4	0.4	0.4
RESISTANCE TO ENVIRONMENTS									
Acids									
Strong	Dissolves in cold HCl, H_2SO_4 and HNO_3			Degraded by oxidizing agents and mineral acids			Dissolves in H_2SO_4		
Weak	Ultimate disintegration in 5% boiling HCl			Weakens on prolonged exposure to acids such as benzoic and oxalic			Good		
Alkalis									
Strong	Inert			Inert			Disintegrates when boiled		
Weak	Inert			Inert			Good		
Other Chemicals	Good			Good			Good		
Heat	Yellows slightly after 5 hr at 300 F; melts at 482 F			Yellows slightly after 5 hr at 300 F; melts at 420 F			Melts at 480 F		
Sunlight (prolonged exposure)	Weakened			Weakened			Weakened		
Microorganisms	Resistant			Resistant			Resistant		
Flame[c]	Self-exting			Self-exting			Burns slowly		

[a] Ratio of breaking stress to breaking strain (i.e., gm/den to rupture divided by strain in cm/gage cm at breaking stress).
[b] Recovery after 2% strain, except where specific percentage strain is given in parenthesis.
[c] Basic flammability of untreated fiber.

Synthetic Fibers

Type →	Vinyl Derivatives					Polyolefins		
	Vinyl Chloride-Acetate (Vinyon)	Vinylidene Chloride (saran)			Polyvinyl Alcohol (Vinylon)	Polyethylene		Polypropylene
		Monofilament	Filament	Staple		Type I	Type III	
NATURE OF FIBER								
Length, in.	Staple	—	—	—	Staple	Monofilament		Monofilament
Width, μ	16–18	1300	50	—	—	250–1300		—
Cross Section	Barbell	Circular	Circular	Circular	Peanut	Circular		Circular
PHYSICAL AND MECHANICAL PROPERTIES								
Specific Gravity	1.33–1.35	1.7	1.7	1.7	1.26–1.30	0.92	0.95–0.96	0.90–0.91
Breaking Tenacity, gm/den								
70 F, 65% RH	0.7–1.0	1.2–2.3	Up to 2	Up to 1.5	4.4–6.0	1.0–3.0	5.0–7.3	5.5–7.0
Wet	0.7–1.0	1.2–2.3	Up to 2	Up to 1.5	3.7–5.0	1.0–3.0	5.0–7.3	5.5–7.0
Ten Str (70 F, 65% RH), 1000 psi	12–17	15–45	44	33	—	11–35	50–90	—
Breaking Elongation, %								
70 F, 65% RH	100–120	20–30	15–25	15–25	15–17	20–80	10–40	12–25
Wet	100–120	20–30	15–25	15–25	—	20–80	10–40	—
Stiffness (avg), gm/den[a]	1.5	7–10	8–12	8–12	24–40	2–12	20–50	—
Strain Recovery (at 2%), %[b]	—	95 (10%)	95 (10%)	95 (10%)	—	90–95 (5%)	Slow	—
Toughness (avg), gm-cm/den-cm	1.3	0.17–0.27	0.125	0.125	0.79–0.92	0.3	—	—
Moisture Regain (70 F, 65% RH), %	Up to 0.5	None	None	None	4.5–5.0	None	None	—
RESISTANCE TO ENVIRONMENTS								
Acids								
Strong	Exc	Exc; fair to conc H_2SO_4			—	Exc to all but oxidizing		Similar to polyethylene
Weak	Exc	Exc			—			
Alkalis								
Strong	Exc	Exc except for ammonium hydroxide			—	Exc	Exc	Exc
Weak	Exc	Exc			—	Exc	Exc	Exc
Other Chemicals	Soluble in some chlorinated hydrocarbons	Some effect from esters and others			—	Some swelling and weakening in benzene, toluene, etc.		Similar to polyethylene
Heat	Tacky, shrinks at 150 F, softens at 170 F, melts at 260 F	Softens at 240–280 F			Melts 420–450 F	Melts at 225 F	Melts at 265–280 F	Melts at 325–335 F
Sunlight (prolonged exposure)	Resistant	Tends to yellow			—	Resistant if pigmented		Resistant if pigmented
Microorganisms	Resistant	Resistant			Resistant	Resistant		Resistant
Flame[c]	Self-exting	Self-exting			Burns slowly	Burns slowly		Burns slowly

[a] Ratio of breaking stress to breaking strain (i.e., gm/den to rupture divided by strain in cm/gage cm at breaking stress).
[b] Recovery after 2% strain except where specific percentage strain is given in parentheses.
[c] Basic flammability of untreated fiber.

Inorganic Fibers

Type ➔	Glass [a]	Asbestos (chrysotile)	Aluminum Silicate (Fiberfrax)
NATURE OF FIBER			
Length, in.	Filament, staple	Crude ⅜–2 in.	¼–10 in. staple
Width, μ	5–16	0.1	2–20 (mean)
Cross Section	Circular	—	—
PHYSICAL AND MECHANICAL PROPERTIES			
Specific Gravity	2.54	2.4–2.6	2.73
Breaking Tenacity, gm/den			
70 F, 65% RH	6.0–7.3	2.5–3.1	1.4–6.5[h]
Wet	3.9–4.7	—	—
Ten Str (70 F, 65% RH), 1000 psi	200–220	80–100	50–230
Breaking Elongation, %			
70 F, 65% RH	2.0–3.75	—	1.4–2.7[i]
Wet	—	—	—
Stiffness (avg), gm/den[b]	322	—	—
Strain Recovery (at 2%), %[c]	100 (3%)	—	—
Toughness (avg), gm-cm/den-cm	0.07	—	—
Moisture Regain (70 F, 65% RH), %	0	—	—
RESISTANCE TO ENVIRONMENTS			
Acids			
Strong	Attacked only by hydrofluoric and hot phosphoric	Good (cold) to poor (hot)	Seems to have chemical resistance similar to borosilicate glass fibers
Weak	Stable	Good (cold) to poor (hot)	
Alkalis			
Strong	Resists most	Good	
Weak	Resists most	Good	
Other Chemicals	Exc	—	
Heat	600–2000 F[e]	750–1490 F[g]	2300 F max use temp; 3300 F melting point
Sunlight (prolonged exposure)	Inert[f]	Inert	Inert
Microorganisms	Unaffected	Unaffected	Unaffected
Flame[d]	Nonflammable	Nonflammable	Nonflammable

[a] Properties may vary widely depending on glass composition; values here indicative of those of borosilicate.
[b] Ratio of breaking stress to breaking strain (i.e., gm/den to rupture divided by strain in cm/gage cm at breaking stress).
[c] Recovery after 2% strain, except where specific percentage strain is given in parentheses.
[d] Basic flammability of untreated fiber.
[e] Normal glass limited to 600 F; quartz fiber generally useful up to 2000 F, though some shrinkage occurs.
[f] Specific types available with excellent weathering characteristics.
[g] Structure is stable up to 1490 F; at temperatures of 750 F and above, substantial amounts of water of crystallization are lost
[h] Average is 3.3 gm/den.
[i] Average is 1.7%.

Woods and Wood-Base Compositions

AMERICAN AND IMPORTED WOODS

Type	Moisture Content, %	Specific Gravity (oven dry)	Static Bending: Mod of Rupture, 1000 psi	Static Bending: Mod of Elast, 10^6 psi	Max Crush Str (par. to grain), 1000 psi	Hardness, lb[a]: End	Hardness, lb[a]: Side	Max Shear Str (par. to grain), psi
AMERICAN HARDWOODS[b]								
Ash (white)	12	0.60	15.4	1.8	7.4	1720	1320	1950
Basswood	12	0.37	8.7	1.5	4.7	520	410	990
Beech	12	0.64	14.9	1.7	7.3	1590	1300	2010
Birch (yellow)	12	0.62	16.6	2.0	8.2	1480	1260	1880
Cottonwood (black)	12	0.35	8.3	1.3	4.4	1020	540	350
Elm (rock)	12	0.63	14.8	1.5	7.1	1920	1510	1320
Hickory (shag bark)	12	0.72	20.2	2.2	9.2	2430	—	—
Locust (black)	12	0.69	19.4	2.1	10.2	2480	1580	1700
Maple (sugar)	12	0.63	15.8	1.8	7.8	2330	1840	1450
Oak (red, white)	12, 12	0.63, 0.68	14.3, 15.2	1.8, 1.8	6.8, 7.4	1780, 2000	1580, 1520	1290, 1360
Poplar (yellow)	12	0.42	10.1	1.6	5.5	1190	670	540
Walnut (black)	12	0.55	14.6	1.7	7.6	1370	1050	1010
AMERICAN SOFTWOODS[b]								
Cedar (Port Orford)	12	0.42	11.3	1.3	6.5	1080	730	560
Cedar (Eastern red)	12	0.47	8.8	0.9	6.0	—	900	900
Cypress (Southern bald)	12	0.46	10.6	1.4	6.4	1000	660	510
Douglas Fir (coast type)	12	0.48	12.2	2.0	7.4	1160	900	710
Fir (balsam)	12	0.36	7.6	1.2	4.5	710	510	400
Hemlock (Eastern, Western)	12, 12	0.40, 0.42	8.9, 10.1	1.2, 1.5	5.4, 6.2	1060, 1170	810, 940	500, 580
Pine (Eastern white)	12	0.35	8.6	1.2	4.8	900	480	380
Pine (longleaf, ponderosa)	12, 12	0.58, 0.40	14.7, 9.2	2.0, 1.3	8.4, 5.3	1500, 1160	920, 550	870, 450
Redwood (virgin)	12	0.40	10.0	1.3	6.2	940	790	480
Spruce (sitka)	12	0.40	10.2	1.6	5.6	1150	760	510
IMPORTED WOODS								
Balsa (tropical America)	5	0.14	2.2	0.5	1.0	—	—	—
Lignum Vitae (tropical America)	12	1.09	—	—	11.4	3600	4500	—
Ebony (Africa)	12	—	26.0	2.7	12.9	3430	3220	2480
Teak (Asia)	52	—	11.4	1.7	5.9	915	1038	1107
Mahogany (tropical America)	12	0.50	11.1	1.4	6.4	880	760	1050
Lemonwood (tropical America)	14	0.78	22.3	2.3	9.7	2140	1940	2120

[a] Load required to embed an 0.444-in. ball to half its diameter. [b] Seasoned.

WOOD COMPOSITION BOARD

Material	Hardboard (fibrous)[a]: Untempered	Hardboard (fibrous)[a]: Tempered	Hardboard (fibrous)[a]: Super Hardboard	Particle Board[b]: Medium Density[d]	Particle Board[b]: Hard Pressed	Softboard (insulation)[c]: Structural Insulating	Softboard (insulation)[c]: Medium Density
PHYSICAL PROPERTIES							
Specific Gravity	0.08–1.28	0.96–1.28	1.36–1.44	0.42–0.80	0.80–1.28	0.16–0.42	0.42–0.80
Density, lb/cu ft	50–80	60–80	85–90	26–50	50–80	10–26	26–50
Ther Cond, Btu/hr/sq ft/°F/in.	0.80–1.40	1.10–1.50	1.85	0.40–1.0	1.10–1.50	0.27–0.45	0.50–0.60
Water Abs (24 hr), %	3–30	3–20	0.3–1.2	20–75	15–40	—	6–150
Max Linear Exp, %[e]	0.60	0.4	—	0.6	0.85	0.50	0.2–1.3[f]
MECHANICAL PROPERTIES							
Ten Str, psi							
Par. to Surface	3000–6000	4000–7800	7800	500–4000	1000–5000	200–500	800–2000
Perp to Surface	—	—	500	40–400	275–400	10–25	—
Mod of Elast in Bend, 1000 psi	400–800	800–1000	1250	150–700	400–1000	25–125	90–700
Compr Str (par.), psi	1800–6000	4200–6000	26,500	1400–2800	3500–4000	—	500–3400
Mod of Rupture, 1000 psi	3–7	6.5–10	10–12.5	1.5–8.0	3.0–7.5	0.2–0.8	0.4–4.0

[a] Made by felting ligno-cellulosic wood fibers formed by steam exploding or mechanical fiberizing.
[b] Made of flakes, chips, splinters or particles of wood bonded with synthetic resin or other binder.
[c] Made from wood pulp or bagasse (processed sugar cane), bonded by felting properties of fiber.
[d] Does not include extruded board.
[e] Expansion resulting from change in moisture content from equilibrium at 50% RH to equilibrium at 90% RH.
[f] For homogeneous and laminated boards, respectively.

Wool Felts—Roll[a]

Grade →	18R1	16R1	16R2	16R3	12R1	12R2
SAE Spec. No. →	—	F-1	F-2	F-3	F-5	F-6
GENERAL PROPERTIES						
Wool Content (fiber basis), min %	100	100	100	95	100	100
Standard Thickness Range, in.	⅛ to 1	⅛ to 1	⅛ to 1	⅛ to 1	⅛ to 1	⅛ to 1
Standard Width, in.	60	60	60	60	60	60 or 72
Texture	Fine	Fine	Med fine	Medium	Fine	Med fine
Color[b]	White	White	Any, except gray or blk	Gray	White	Gray
PHYSICAL PROPERTIES						
Specific Gravity	0.384	0.342	0.342	0.330	0.262	0.262
Operating Temp Range, F[c]	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200
Ther Cond (70 F), Btu/hr/sq ft/°F/in.[d]	0.39	0.36	0.36	0.35	0.30	0.30
Coef of Ther Exp, per °F	0	0	0	0	0	0
Air Perm (1/16 in.), cfm/sq ft/0.5 in. H_2O	5–15	10–30	10–30	15–35	20–50	20–50
Liquid Absorption, %						
By Weight (1.0 sp gr liquid)	>125	>175	>175	>190	>250	>225
By Volume	71	74	74	76	80	80
Capillarity (wicking height, 575 SSU, 70 F), in.	4.5	4.0	4.0	4.0	3.0	3.0
Coef of Friction[e]	0.37	0.37	0.37	0.37	0.37	0.37
Vibration Absorption[f]						
Static Load Bearing Cap, per Unit Area	High	High	High	High	Medium	Medium
Dynamic Stress Endurance	High	High	High	High-med	High	High
Coef of Noise Reduction (1 in. thick)[d]	0.45	0.50	0.50	0.52	0.58	0.58
MECHANICAL PROPERTIES						
Ten Str (min), psi	600	500	500	400	400	275
Elong (at 100 psi), %	9	13	14	16	16	18
Mullen Burst Str (⅛ in. thick), psi	300	250	225	200	175	150
Split Res (min), lb/2-in. width	35	33	28	22	18	16
Hardness Range, Shore A	40–50	30–40	30–40	30–40	20–30	20–30
Compressibility (at 10% defl), psi	37	21	21	13	6	6
Recovery (within 1 min after 10% defl), %	99	99	99	99	99	99
Vibration Disintegration	None	None	None	None	None	None
Collapse When Wet	None	None	None	None	None	None
Abrasion Resistance[g]	Excellent	Excellent	Excellent	Excellent	Good	Good
Flexibility (fold endurance)	¼-in. thick felt exceeds 3 million 180° flexes					
CHEMICAL AND ENVIRONMENTAL PROPERTIES[h]						
Effect of Sunlight and Oxidation	None	None	None	None	None	None
Solvent Res, Stability in Oil	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Acid Resistance						
Dilute	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Concentrated	Good-fair	Good-fair	Good-fair	Good-fair	Good-fair	Good-fair
Alkali Resistance						
Dilute	Fair	Fair	Fair	Fair	Fair	Fair
Concentrated	Poor	Poor	Poor	Poor	Poor	Poor
FABRICATING METHODS	Can be fabricated by die-cutting, stripping, skiving; laminating, coating, impregnating; stitching, stapling, perforating, cementing; machining, grinding, drilling; and molding and shaping. All grades except 12R1 and 12R2 can be extruded					
TYPICAL USES	Bearing seals, ink rolls, polishing, printing, wick lubrication, and precision uses where dense high grade felt with max durability is required		Vibration mounts, precision channels, oil seals, bumpers, gaskets	Automotive, aircraft, machine components. Similar to 16R1 and 16R2, where lower density is acceptable	Lubricators, wipers, shock dampeners, etc., where durable resilient felt is required	Grease retainers, spacer strip seals, vibration mounts, weatherstrip, journal lubricators

[a] Industrial, mechanical and filter felts; three dimensional fibrous structure.
[b] Colors available on special order. [c] Felts are flameproofed to meet government and industrial specifications.
[d] For 1-in. felts. Felts blended with kapok fiber have a k factor of 0.21 and a coefficient of sound absorption of 0.80 at 512 cps.
[e] Depends upon condition of contact surface, but can be moderately controlled by altering surface finish of the felt.
[f] Up to 85% under appropriate design conditions. [g] Increases with density. [h] Treated to resist moths, fungus, mildew and vermin.

Wool Felts—Roll[a]

Grade ➜	12R3	9R1	9R2	9R3	9R4	9R5
SAE Spec. No. ➜	F-7	F-10	F-11	F-12	F-13	F-15
GENERAL PROPERTIES						
Wool Content (fiber basis), min %	85	100	100	90	80	60
Standard Thickness Range, in.	⅛ to 1	⅛ to 1	⅛ to 1	⅛ to 1	⅛ to 1	⅛ to 1
Standard Width, in.	72	72	72	72	72	72
Texture	Medium	Fine	Med fine	Med fine	Medium	Medium
Color[b]	Gray	White	Gray	Gray	Gray	Gray
PHYSICAL PROPERTIES						
Specific Gravity	0.262	0.181	0.181	0.181	0.181	0.181
Operating Temp Range, F[c]	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200
Ther Cond (70 F), Btu/hr/sq ft/°F/in.[d]	0.30	0.30	0.24	0.24	0.24	0.24
Coef of Ther Exp, per °F	0	0	0	0	0	0
Air Perm (1/16 in.), cfm/sq ft/0.5 in. H_2O	20–50	75–150	75–150	75–150	75–150	75–150
Liquid Absorption, %						
By Weight (1.0 sp gr liquid)	>225	>400	>375	>350	>350	>350
By Volume	80	88	88	88	88	88
Capillarity (wicking height, 575 SSU, 70 F), in.	3.0	2.5	2.5	2.5	2.5	2.5
Coef of Friction[e]	0.37	0.37	0.37	0.37	0.37	0.37
Vibration Absorption[f]						
Static Load Bearing Cap, per Unit Area	Medium	Low	Low	Low	Low	Low
Dynamic Stress Endurance	Medium	High	High-med	Medium	Low	Low
Coef of Noise Reduction (1 in. thick)	0.58	0.58	0.64	0.64	0.64	0.64
MECHANICAL PROPERTIES						
Ten Str (min), psi	250	225	200	100	75	75
Elong (at 100 psi), %	21	33	35	35	37	39
Mullen Burs Str (⅛ in. thick), psi	125	75	60	55	50	40
Split Res (min), lb/2-in. width	12	8	6	3	2	2
Hardness Range, Shore A	20–30	15–25	15–25	15–25	15–25	15–25
Compressibility (at 10% defl), psi	6	4	4	3	3	3
Recovery (within 1 min after 10% defl), %	99	99	99	99	99	99
Vibration Disintegration	None	None	None	None	None	None
Collapse When Wet	None	None	None	None	None	None
Abrasion Resistance[g]	Good	Fair	Fair	Fair	Fair	Fair
Flexibility (Fold endurance)	¼-in. thick felt exceeds 3 million 180° flexes					
CHEMICAL AND ENVIRONMENTAL PROPERTIES[h]						
Effect of Sunlight and Oxidation	None	None	None	None	None	None
Solvent Res and Stability in Oil	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Acid Resistance						
Dilute	Good	Excellent	Excellent	Good	Fair	Fair
Concentrated	Fair	Fair-good	Fair-good	Fair-good	Fair	Fair
Alkali Resistance						
Dilute	Fair	Fair	Fair	Fair	Fair	Fair
Concentrated	Poor	Poor	Poor	Poor	Poor	Poor
FABRICATING METHODS	Can be fabricated by die-cutting, stripping, skiving; laminating, coating, impregnating; stitching, stapling, perforating, cementing; and molding and shaping. Grade 12R3 can also be machined, ground and drilled					
TYPICAL USES	Dust shields, oil and grease retainers; similar to 12R1 and 12R2 where a lower grade may be used	Fluid storage and delivery, resilient padding, plug filters for gas and air	Dryer drum seals, impregnated packing, insoles, insulation; oil, dust and mud shields	Chassis strips, spacers, dash liners, anti-squeak strips and pads, sound deadening	Grease and oil retention, protective lining and insulation for freight cars, trucks, dunnage; uses similar to 9R2 and 9R3 where less durability and lower grade felt is suitable	

[a] Notes on opposite page.

continued on next page

Wool Felts—Roll and Sheet[a]

Grade →	8R5	16R1X	16R3X	12R3X	32S1	32S2
SAE Spec. No. →	F-26	F-50	F-51	F-55	—	—
GENERAL PROPERTIES						
Wool Content (fiber basis), min %	50	100	100	80	100	100
Standard Thickness Range, in.	1/8 to 1	3/64 to 3/32	3/64 to 3/32	1/16 to 3/32	1/8 to 3	1/8 to 3
Standard Width, in.	72	60 or 72	60 or 72	60 or 72	36 x 36	36 x 36
Texture	Medium	Fine	Med fine	Medium	Extra fine	Fine
Color[b]	Gray	White	Gray	Gray or blk	White	White
PHYSICAL PROPERTIES						
Specific Gravity	0.154	0.330	0.330	0.256	0.682	0.682
Operating Temp Range, F[c]	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200
Ther Cond (70 F), Btu/hr/sq ft/°F/in.[d]	0.25	0.32	0.32	0.30	0.91	0.91
Coef of Ther Exp, per °F	0	0	0	0	0	0
Air Perm (1/16 in.), cfm/sq ft/0.5 in. H_2O	100–200	15–25	15–40	20–50	<1	<1
Liquid Absorption, %						
By Weight (1.0 sp gr liquid)	>400	>180	>170	>225	>50	>50
By Volume	92	75	75	81	48	48
Capillarity (wicking height, 575 SSU, 70 F), in.	—	4.0	4.0	3.0	5.5	5.5
Coef of Friction[e]	0.37	0.37	0.37	0.37	0.42	0.42
Vibration Absorption[f]						
Static Load Bearing Cap, per Unit Area	Very low	—	—	—	Ultra high	Ultra high
Dynamic Stress Endurance	Very low	—	—	—	High	High
Coef of Noise Reduction (1 in. thick)[d]	0.65	0.55	0.55	0.58	0.05	0.05
MECHANICAL PROPERTIES						
Ten Str (min), psi	—	500	200	200	800	800
Elong (at 100 psi), %	—	8	9	25	2	2
Mullen Burst Str (1/8 in. thick), psi	25	225	225	200	Over 500	Over 500
Split Res (min), lb/2-in. width	—	—	—	—	50	48
Hardness Range, Shore A	5–15	—	—	—	75–85	75–85
Compressibility (at 10% defl), psi	1	—	—	—	121	121
Recovery (within 1 min after 10% defl), %	99	99	99	99	99	99
Vibration Disintegration	None	None	None	None	None	None
Collapse When Wet	Slight	None	None	None	None	None
Abrasion Resistance[g]	Poor	Excellent	Excellent	Good	Excellent	Excellent
Flexibility (fold endurance)	1/4-in. thick felt exceeds 3 million 180° flexes					
CHEMICAL AND ENVIRONMENTAL PROPERTIES[h]						
Effect of Sunlight and Oxidation	None	None	None	None	None	None
Solvent Res and Stability in Oil	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Acid Resistance						
Dilute	Fair	Excellent	Excellent	Good	Excellent	Excellent
Concentrated	Poor	Fair-good	Fair-good	Fair	Fair-good	Fair-good
Alkali Resistance						
Dilute	Fair	Fair	Fair	Fair	Fair	Fair
Concentrated	Poor	Poor	Poor	Poor	Poor	Poor
FABRICATING METHODS	Can be fabricated by die-cutting, stripping, skiving; laminating, coating, impregnating; stitching, stapling, perforating, cementing; and molding and shaping. Grades 32S1 and 32S2 can also be machined, ground, drilled or extruded					
TYPICAL USES	Packing or padding when held between other materials; not recommended for mechanical use	Ball and roller bearing precision seals, strip wicks, industrial filters and uses requiring thin precision felt	Gaskets, liners, bearing seals, where precision tolerances, life and quality are not as exacting	Anti-squeak strips, anti-drumming and insulation lining cemented to metal or other type panels	Extra-hard density polishing wheels and buffs in dental jewelry, glass and lapidary polishing; also hard washers, bumpers and casters	

[a] Industrial, mechanical and filter felts; three dimensional fibrous structure.
[b] Colors available on special order. [c] Felts are flameproofed to meet government and industrial specifications.
[d] For 1-in. felts. Felts blended with kapok fiber have a k factor of 0.21 and a coefficient of sound absorption of 0.80 at 512 cps.
[e] Depends upon condition of contact surface, but can be moderately controlled by altering surface finish of the felt.
[f] Up to 85% under appropriate design conditions. [g] Increases with density. [h] Treated to resist moths, fungus, mildew and vermin.

Wool Felts—Sheet[a]

Grade ➡	32S3	32S4	26S1	26S2	26S3	26S4
GENERAL PROPERTIES						
Wool Content (fiber basis), min %	100	100	100	100	100	100
Standard Thickness Range, in.	⅛ to 3	⅛ to 3	⅛ to 3	⅛ to 3	⅛ to 3	⅛ to 3
Standard Width, in.	36 x 36	36 x 36	36 x 36	36 x 36	36 x 36	36 x 36
Texture	Medium	Coarse	Extra fine	Fine	Med fine	Coarse
Color[b]	White	White	White	White	White	White
PHYSICAL PROPERTIES						
Specific Gravity	0.682	0.682	0.555	0.555	0.555	0.555
Operating Temp Range, F[c]	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200
Ther Cond (70 F), Btu/hr/sq ft/°F/in.[d]	0.91	0.91	0.63	0.63	0.63	0.63
Coef of Ther Exp, per °F	0	0	0	0	0	0
Air Perm (1/16 in.), cfm/sq ft/0.5 in. H_2O	<1	<1	<3	<3	<5	<5
Liquid Absorption, %						
By Weight (1.0 sp gr liquid)	>50	>50	>75	>75	>75	>75
By Volume	48	48	58	58	58	58
Capillarity (wicking height, 575 SSU, 70 F), in.	5.5	5.5	5.0	5.0	5.0	5.0
Coef of Friction[e]	0.42	0.42	0.42	0.42	0.42	0.42
Vibration Absorption[f]						
Static Load Bearing Cap, per Unit Area	Ultra high	Ultra high	Very high	Very high	Very high	Very high
Dynamic Stress Endurance	Med-high	Medium	High	High	Med-high	Medium
Coef of Noise Reduction (1 in. thick)	0.05	0.05	0.28	0.28	0.28	0.28
MECHANICAL PROPERTIES						
Ten Str (min), psi	800	800	700	700	700	700
Elong (at 100 psi), %	2	2	4	4	4	4
Mullen Burst Str (⅛ in. thick), psi	>500	>500	>400	>400	>400	>400
Split Res (min), lb/2-in. width	46	40	48	46	40	30
Hardness Range, Shore A	75–85	75–85	55–65	55–65	55–65	55–65
Compressibility (at 10% defl), psi	121	121	86	86	86	86
Recovery (within 1 min after 10% defl), %	99	99	99	99	99	99
Vibration Disintegration	None	None	None	None	None	None
Collapse When Wet	None	None	None	None	None	None
Abrasion Resistance[g]	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Flexibility (fold endurance)	¼-in. thick felt exceeds 3 million 180° flexes					
CHEMICAL AND ENVIRONMENTAL PROPERTIES[h]						
Effect of Sunlight and Oxidation	None	None	None	None	None	None
Solvent Res and Stability in Oil	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Acid Resistance						
Dilute	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Concentrated	Fair-good	Fair-good	Fair-good	Fair-good	Fair-good	Fair-good
Alkali Resistance						
Dilute	Fair	Fair	Fair	Fair	Fair	Fair
Concentrated	Poor	Poor	Poor	Poor	Poor	Poor
FABRICATING METHODS	Die cutting, stripping, skiving; laminating, coating, impregnating; stitching, stapling, perforating cementing; machining, grinding, drilling; molding and shaping; extruding					
TYPICAL USES	Similar to those indicated for 32S1 and 32S2	Hard-density wheels for polishing glass sheet, glassware, opthalmic lenses, metal and metallographic samples, wood and furniture; also block cutters, print rolls, cash carrier heads, marking pen nibs, casters, boot and shoe soles, artificial limbs				

[a] Notes on opposite page.

continued on next page

Wool Felts—Sheet[a]

Grade →	20S1	20S2	20S3	20S4	16S1	16S2
GENERAL PROPERTIES						
Wool Content (fiber basis), min %	100	100	100	100	100	100
Standard Thickness Range, in.	1/8 to 3	1/8 to 3	1/8 to 3	1/8 to 3	1/8 to 3	1/8 to 3
Standard Width, in.	36 x 36	36 x 36	36 x 36	36 x 36	36 x 36	36 x 36
Texture	Extra fine	Fine	Medium	Coarse	Extra fine	Fine
Color[b]	White	White	White	White	White	White
PHYSICAL PROPERTIES						
Specific Gravity	0.426	0.426	0.426	0.426	0.342	0.342
Operating Temp Range, F[c]	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200
Ther Cond (70 F), Btu/hr/sq ft/°F/in.[d]	0.45	0.45	0.45	0.45	0.36	0.36
Coef of Ther Exp, per °F	0	0	0	0	0	0
Air Perm (1/16 in.), cfm/sq ft/0.5 in. H_2O	<10	<10	<15	<15	<20	<25
Liquid Absorption, %						
By Weight (1.0 sp gr liquid)	>100	>100	>100	>100	>175	>175
By Volume	66	66	66	66	74	74
Capillarity (wicking height, 575 SSU, 70 F), in.	4.5	4.5	4.5	4.5	4.0	4.0
Coef of Friction[e]	0.42	0.42	0.42	0.42	0.37	0.37
Vibration Absorption[f]						
Static Load Bearing Cap, per Unit Area	High	High	High	High	High	High
Dynamic Stress Endurance	High	High-med	Med-high	Medium	High	High-med
Coef of Noise Reduction (1 in. thick)[d]	0.41	0.41	0.41	0.41	0.50	0.50
MECHANICAL PROPERTIES						
Ten Str (min), psi	600	600	600	600	500	500
Elong (at 100 psi), %	9	9	9	9	12	12
Mullen Burst Str (1/8 in. thick), psi	325	325	325	325	250	250
Split Res (min), lb/2-in. width	44	40	36	32	32	28
Hardness Range, Shore A	45–55	45–55	45–55	45–55	30–40	30–40
Compressibility (at 10% defl), psi	58	58	58	58	32	32
Recovery (within 1 min after 10% defl), %	99	99	99	99	99	99
Vibration Disintegration	None	None	None	None	None	None
Collapse When Wet	None	None	None	None	None	None
Abrasion Resistance[g]	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Flexibility (fold endurance)	1/4-in. thick felt exceeds 3 million 180° flexes					
CHEMICAL AND ENVIRONMENTAL PROPERTIES[h]						
Effect of Sunlight and Oxidation	None	None	None	None	None	None
Solvent Res and Stability in Oil	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Acid Resistance						
Dilute	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Concentrated	Good-fair	Good-fair	Good-fair	Good-fair	Good-fair	Good-fair
Alkali Resistance						
Dilute	Fair	Fair	Fair	Fair	Fair	Fair
Concentrated	Poor	Poor	Poor	Poor	Poor	Poor
FABRICATING METHODS	Die cutting, stripping, skiving; laminating, coating, impregnating; stitching, stapling, perforating, cementing; machining, grinding, drilling; molding and shaping; extruding					
TYPICAL USES	Medium-hard-density polishing wheels and buffs for polishing lenses, mirrors and glass, and marble and granite; fluid transfer rolls, ink rolls, furniture rubbing, rough metal polishing, metal wiping, drilled wicks, bearing seal washers, stamp pads, cushioning under sandpaper				Medium density polishing wheels and buffs for precious metals and plastics, rough optical polishing, metal wiping; drum beaters, drilled wicks, bearing seals, shoe rolls (shank), fluid transfer rolls, oil and fluid wicks, grease and oil retaining washers, ink rollers, vibration mounts, bumpers, plugs, glass channels	

[a] Industrial, mechanical and filter felts; three dimensional fibrous structure.
[b] Colors available on special order. [c] Felts are flameproofed to meet government and industrial specifications.
[d] For 1-in. felts. Felts blended with kapok fiber have a k factor of 0.21 and a coefficient of sound absorption of 0.80 at 512 cps.
[e] Depends upon condition of contact surface, but can be moderately controlled by altering surface finish of the felt.
[f] Up to 85% under appropriate design conditions. [g] Increases with density. [h] Treated to resist moths, fungus, mildew and vermin.

Wool Felts—Sheet[a]

Grade →	16S3	16S4	12S1	12S2	12S3	12S4
GENERAL PROPERTIES						
Wool Content (fiber basis), min %	100	100	100	100	100	100
Standard Thickness Range, in.	⅛ to 3	⅛ to 3	⅛ to 3	⅛ to 3	⅛ to 3	⅛ to 3
Standard Width, in.	36 x 36	36 x 36	36 x 36	36 x 36	36 x 36	36 x 36
Texture	Medium	Coarse	Extra fine	Fine	Medium	Coarse
Color[b]	White	White	White	White	White	White
PHYSICAL PROPERTIES						
Specific Gravity	0.342	0.342	0.256	0.256	0.256	0.256
Operating Temp Range, F[c]	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200
Ther Cond (70 F), Btu/hr/sq ft/°F/in.[d]	0.36	0.36	0.30	0.30	0.30	0.30
Coef of Ther Exp, per °F	0	0	0	0	0	0
Air Perm (1/16 in.), cfm/sq ft/0.5 in. H_2O	<30	<35	<30	<40	<50	<60
Liquid Absorption, %						
By Weight (1.0 sp gr liquid)	>175	>175	>250	>250	>250	>250
By Volume	74	74	81	81	81	81
Capillarity (wicking height, 575 SSU, 70 F), in.	4.0	4.0	3.0	3.0	3.0	3.0
Coef of Friction[e]	0.37	0.37	0.37	0.37	0.37	0.37
Vibration Absorption[f]						
Static Load Bearing Cap, per Unit Area	High	High	Medium	Medium	Medium	Medium
Dynamic Stress Endurance	Med-high	Medium	High	High-med	Med-high	Medium
Coef of Noise Reduction (1 in. thick)	0.50	0.50	0.58	0.58	0.58	0.58
MECHANICAL PROPERTIES						
Ten Str (min), psi	500	500	400	400	400	400
Elong (at 100 psi), %	12	12	28	28	28	28
Mullen Burst Str (⅛ in. thick), psi	250	250	150	150	150	150
Split Res (min), lb/2-in. width	22	20	18	16	12	10
Hardness Range, Shore A	30–40	30–40	20–30	20–30	20–30	20–30
Compressibility (at 10% defl), psi	32	32	18	18	18	18
Recovery (within 1 min after 10% defl), %	99	99	99	99	99	99
Vibration Disintegration	None	None	None	None	None	None
Collapse When Wet	None	None	None	None	None	None
Abrasion Resistance[g]	Excellent	Excellent	Good	Good	Good	Good
Flexibility (fold endurance)	¼-in. thick felt exceeds 3 million 180° flexes					
CHEMICAL AND ENVIRONMENTAL PROPERTIES[h]						
Effect of Sunlight and Oxidation	None	None	None	None	None	None
Solvent Res and Stability in Oil	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Acid Resistance						
Dilute	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Concentrated	Good-fair	Good-fair	Good-fair	Good-fair	Good-fair	Good-fair
Alkali Resistance						
Dilute	Fair	Fair	Fair	Fair	Fair	Fair
Concentrated	Poor	Poor	Poor	Poor	Poor	Poor
FABRICATING METHODS	Die cutting, stripping, skiving; laminating, coating, impregnating; stitching, stapling, perforating, cementing; machining, grinding, drilling; molding and shaping; extruding					
TYPICAL USES	Medium density polishing wheels and buffs for precious metals and plastics, rough optical polishing, metal wiping; also drum beaters, drilled wicks, bearing seals, shoe rolls (shank), fluid transfer rolls, oil and fluid wicks, grease and oil retaining washers, ink rollers, vibration mounts, bumpers plugs, glass channels		Soft density polishing wheels and buffs for polishing plastics and polishing and wiping brass; also piano wedges, surgical pads, punched wicks, dampeners, absorbent pads, oil and fluid retainers, fluid transfer rolls, bearing seals, washers, wicks, shim and spacer pads, shoe insoles, dust shields			

[a] Notes on opposite page.

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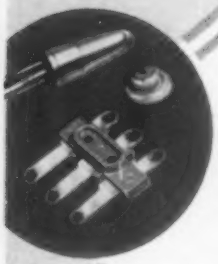

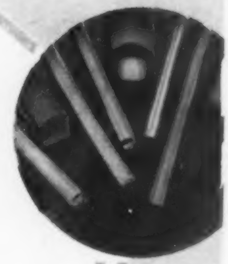

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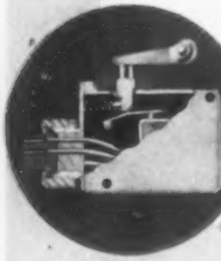

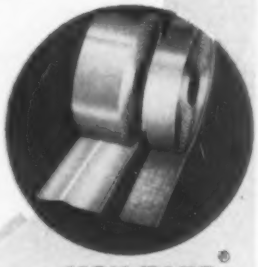

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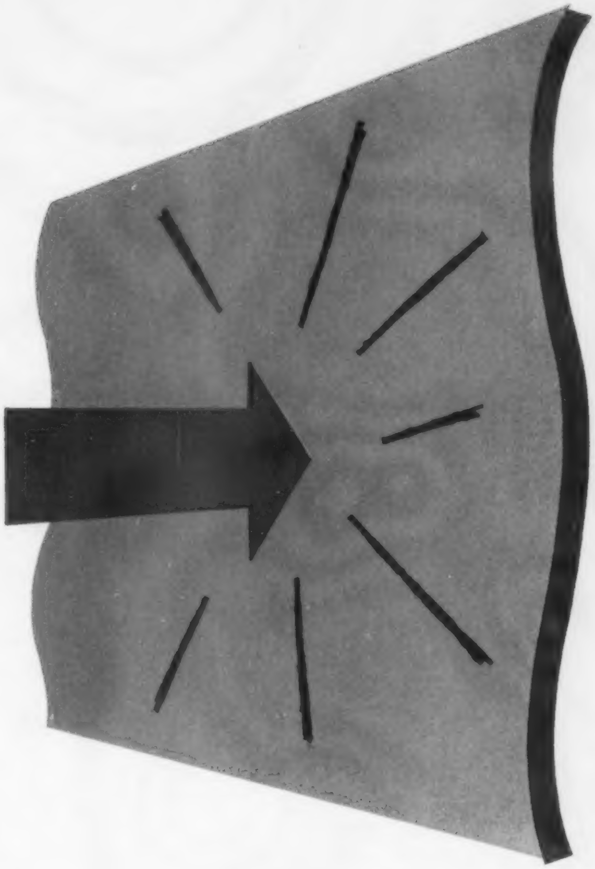

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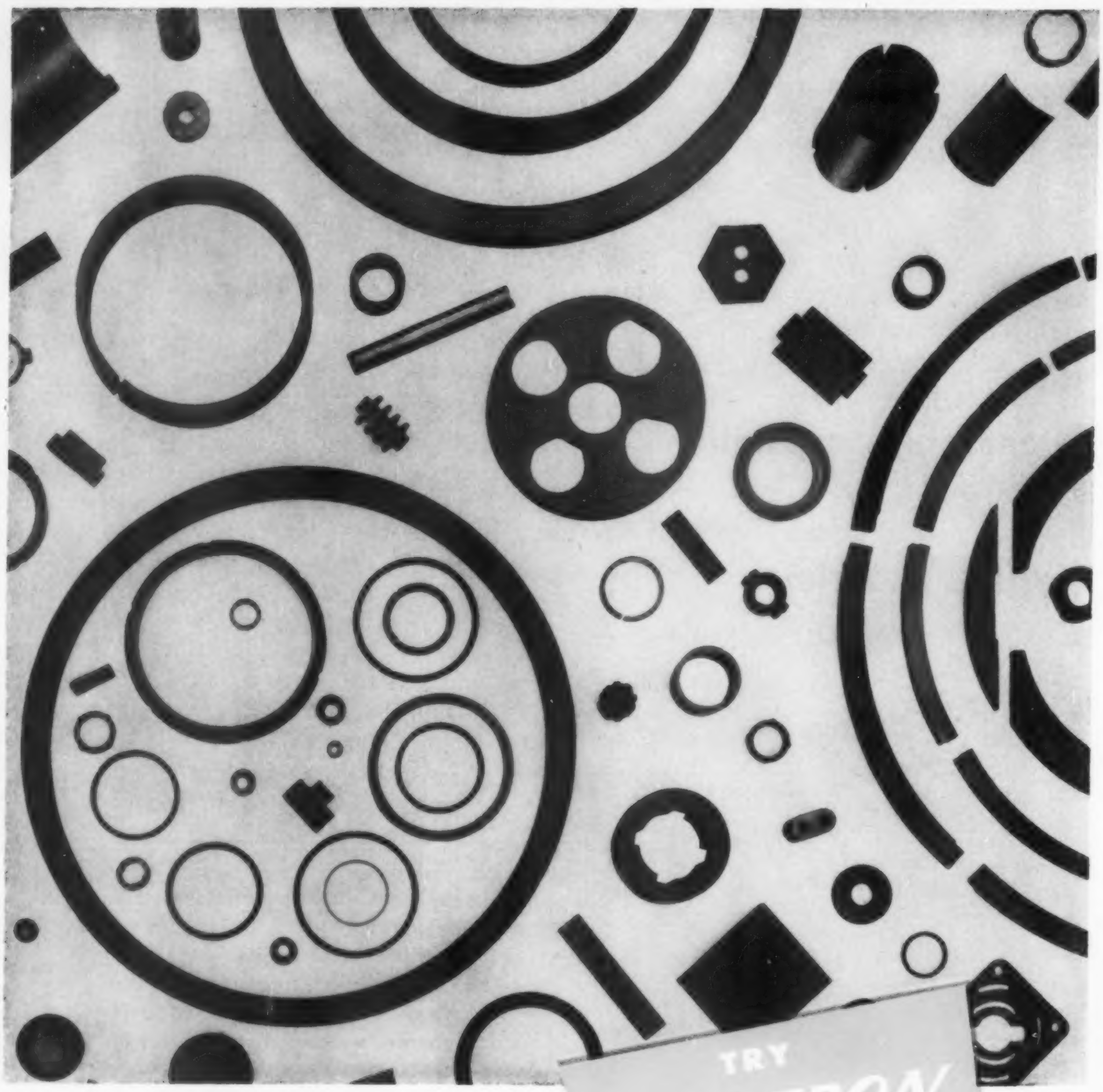

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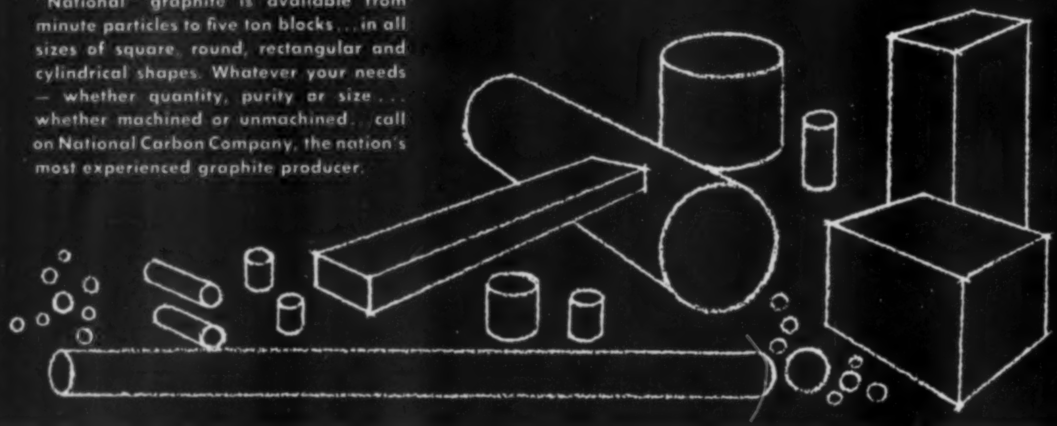

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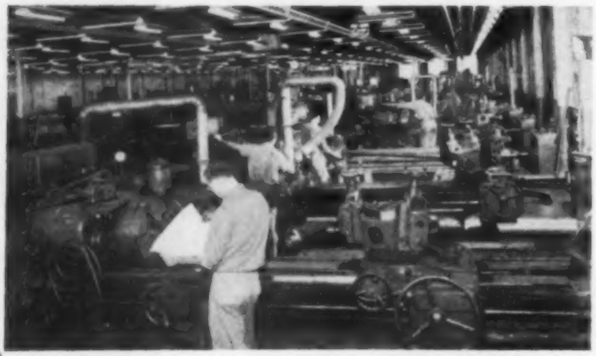

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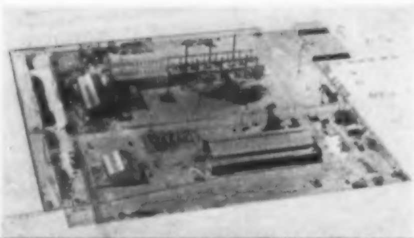

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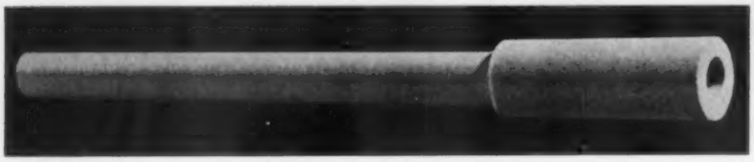

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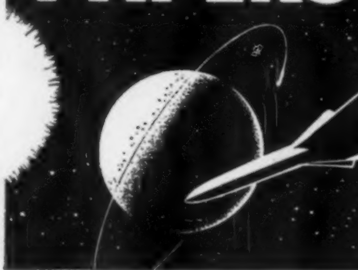

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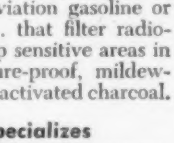

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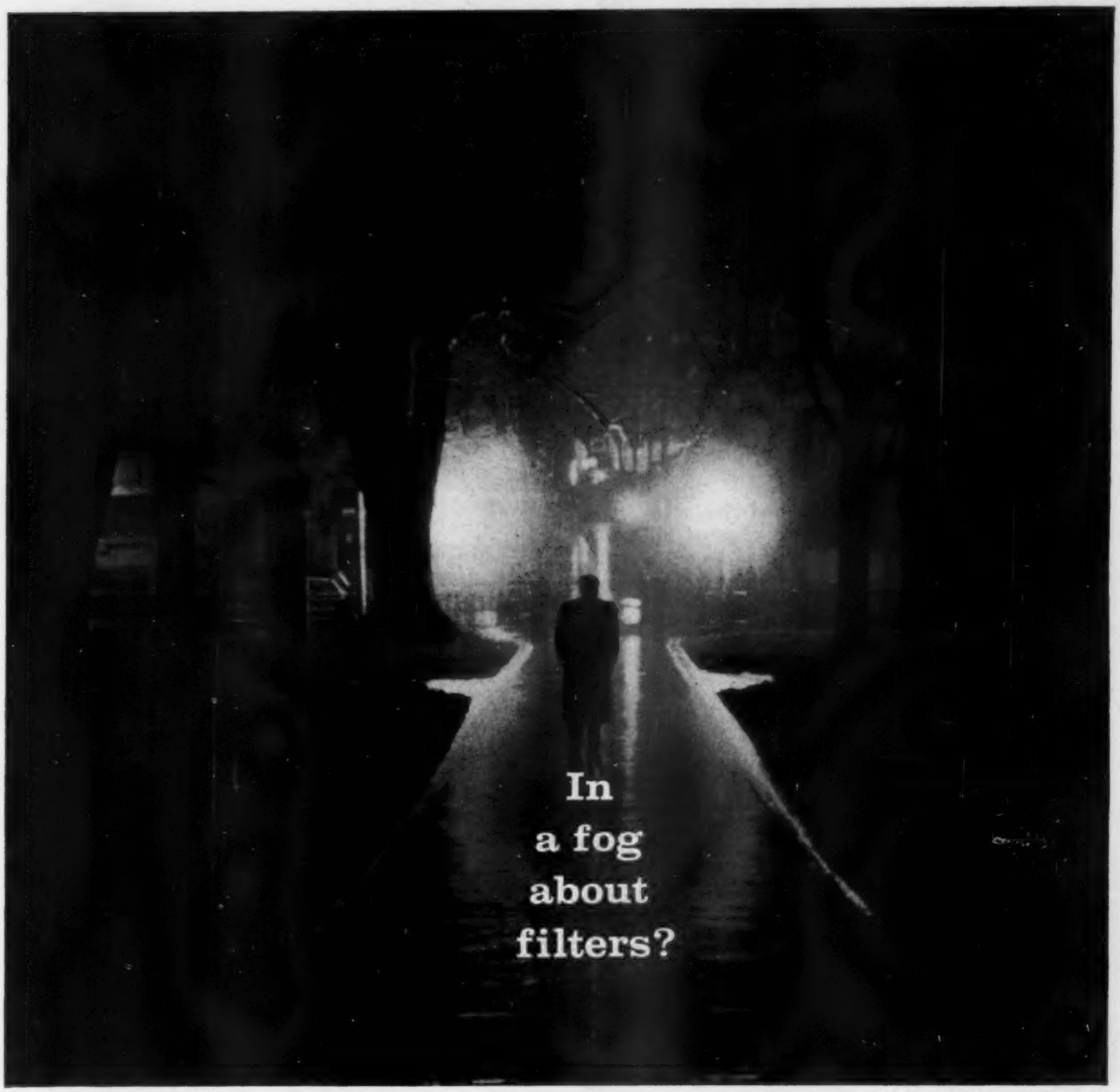

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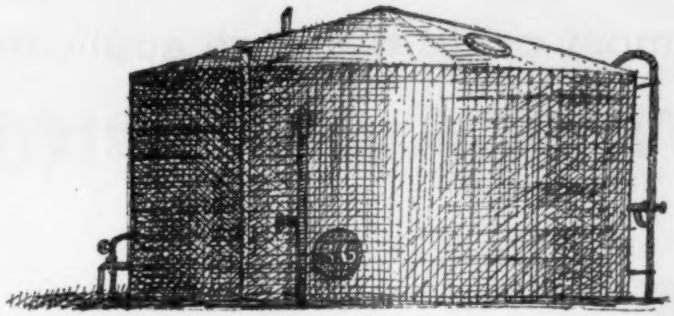

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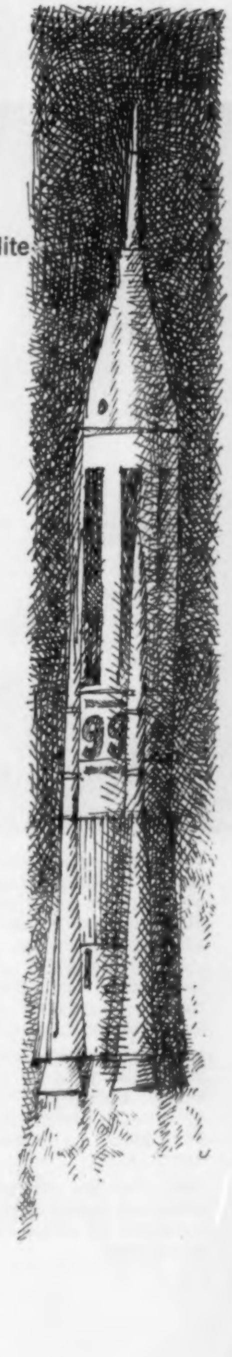

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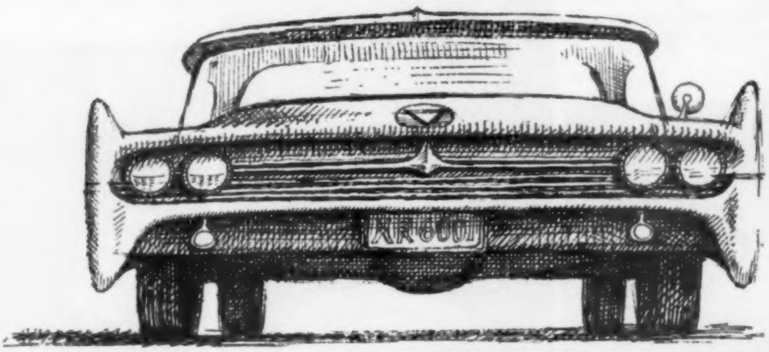

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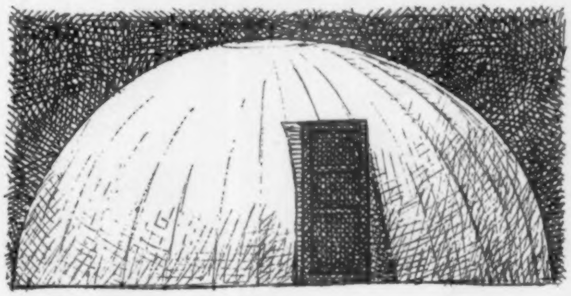

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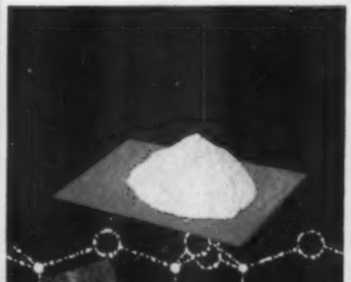

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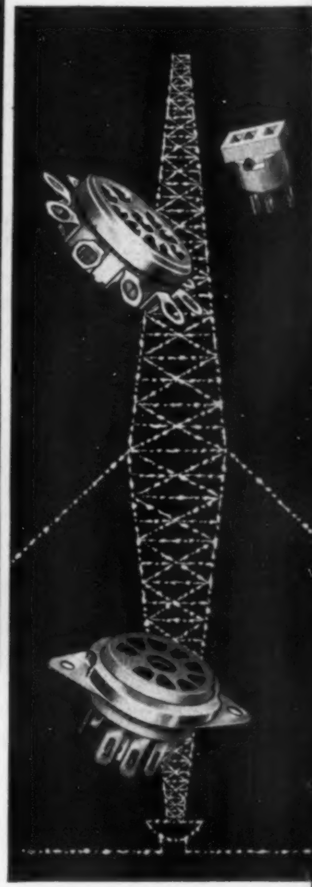

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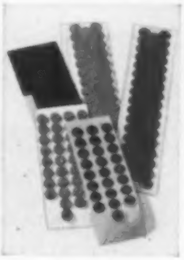

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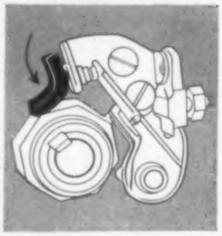
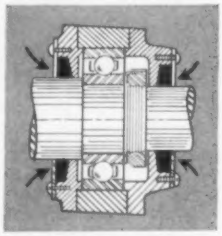


Felt is an ideal wicking and lubricating material which can be designed into special assemblies like this distributor cam shown here. Lubrication is constant, wear reduced, and felt can be shaped to cover all required areas.



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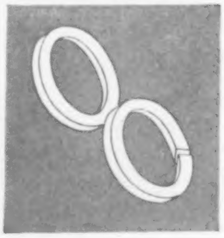

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Galvanized Products. American Hot Dip Galvanizers Assn., 32 pp, illus., No. AZI-40. Manual describes significant factors governing inspection, properties, specification, and purchasing of hot dip zinc coatings. Subjects covered include: thickness and uniformity, coating weight requirements, adherence, embrittlement, warpage and distortion, metallurgical structure of coating, methods of testing, etc. Includes data on product design and a check list of defects, possible causes and recommended action. **150**

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FINISHES AND COATINGS

Electrodeposited Coatings

Type ➔	Aluminum	Antimony	Arsenic	Bismuth	Cadmium	Chromium
BASE METALS	Magnesium, steel, copper, zinc, nickel, silver, gold	(experimental)	Brass	(experimental)	Steel, copper and its alloys, cast and malleable iron	Ferrous and nonferrous metals
PHYSICAL PROPERTIES						
Ther Cond, Btu/hr/sq ft/°F/ft	122	10.2	—	4.6	5.3	—
Elec Res, microhm-cm	2.8	41.7	35	119	7.5	14–66
Color (natural)	White	White (bright)	Gray or black	White or gray	White (bright)	White (bright) or black
Reflectance When Polished (5000 A), %	—	50	—	—	—	—
Melting Point, F	1220	1166	1139	520	610	2939
Min Thickness, mil	0.1	—	—	—	0.15	0.01
MECHANICAL PROPERTIES						
Brinell Hardness	—	—	—	—	35–50	700–1000
Abrasion Resistance[a]	Poor	—	—	—	Fair	Excellent
CORROSION RESISTANCE, 10^{-6} ipy						
Atmosphere	—	—	—	—	250–510	—
Sea Water	20–3400	—	—	—	700	—
SOLDERABILITY						
As Plated	—	—	—	—	Good	Poor
After 192-Hr Salt Spray	—	—	—	—	Poor	Poor
COST	Moderate	—	—	—	Moderate	Moderate
USES[b]	c, e	c, d	D	c	C, d, w	c, D, e, R, W

Type ➔	Cobalt	Copper	Gold	Indium	Iron	Lead
BASE METALS	Iron, steel, copper and its alloys	Most ferrous and nonferrous metals	Copper, brass, nickel, silver	Silver-plated steel	Ferrous metals	Most ferrous and nonferrous metals
PHYSICAL PROPERTIES						
Ther Cond, Btu/hr/sq ft/°F/ft	—	222	169	—	38.7	20.1
Elec Res, microhm-cm	6.2	3–8	2.4	8.4	10	22.6
Color (natural)	Gray	Pink or red (bright)	Yellow (bright)	White	Gray	Gray
Reflectance When Polished (5000 A), %	—	44	47	—	0.55	—
Melting Point, F	2723	1981	1944	311	2795	621
Min Thickness, mil	—	0.1	0.002	0.1	—	0.25
MECHANICAL PROPERTIES						
Brinell Hardness	—	60–150	5	—	150–300	5
Abrasion Resistance[a]	—	Fair	Poor	Poor	Good	Poor
CORROSION RESISTANCE, 10^{-6} ipy						
Atmosphere	—	54–464	—	—	—	9–27
Sea Water	—	2000	—	—	—	400–600
SOLDERABILITY						
As Plated	—	Good	Good	Good	Fair	—
After 192-Hr Salt Spray	—	—	Good	—	Poor	—
COST	—	Low	High	—	Low	Low
USES[b]	c, e, r	c, d, E	c, D, e	c, d, W	e, R, w	C, e, w

Notes: See opposite page.

Electrodeposited Coatings

Type ➡	Magnesium	Manganese	Molybdenum	Nickel	Palladium	Platinum
BASE METALS	(experimental)	Iron, aluminum, copper and its alloys	Zinc, cadmium	Most ferrous and nonferrous metals	Copper and its alloys	Lead, tin, zinc, white gold
PHYSICAL PROPERTIES						
Ther Cond, Btu/hr/sq ft/°F/ft	91	—	83.8	34.4	40.6	40 2
Elec Res, microhm-cm	4.6	5	5.7	7.4–10.8	11	10
Color (natural)	White	Gray	Gray	Gray, white (bright)	Bright	Gray (bright)
Reflectance When Polished (5000 A), %	0.72	—	46	61	—	58
Melting Point, F	1204	2300	4748	2651	2820	3223
Min Thickness, mil	—	—	—	0.1	0.02	Flash
MECHANICAL PROPERTIES						
Brinell Hardness	—	—	—	150–500	—	—
Abrasion Resistance[a]	—	—	Excellent	Excellent	—	—
CORROSION RESISTANCE, 10^{-6} ipy						
Atmosphere	—	—	—	1–160	—	—
Sea Water	10,000–80,000	—	—	300–1000	—	—
SOLDERABILITY						
As Plated	—	—	—	Good	—	—
After 192-Hr Salt Spray	—	—	—	Poor	—	—
COST	—	—	—	Moderate	High	High
USES[b]	Experimental	Experimental	Experimental	C, D, E, R, W	c, D	c, D

Type ➡	Rhenium	Rhodium	Selenium	Silver	Tin	Titanium
BASE METALS	(experimental)	Most ferrous and nonferrous metals	(experimental)	Most ferrous and nonferrous metals	Most ferrous and nonferrous metals	Steel, nickel, copper
PHYSICAL PROPERTIES						
Ther Cond, Btu/hr/sq ft/°F/ft	—	50.9	—	244	36.3	—
Elec Res, microhm-cm	21	4.7	12	1.6	11.5	3.2
Color (natural)	Gray (bright)	White (bright)	Gray	White (bright)	White	—
Reflectance When Polished (5000 A), %	—	76	—	91	—	—
Melting Point, F	5732	3553	423	1760	448	3272
Min Thickness, mil	—	0 001	—	0.1	0.015	—
MECHANICAL PROPERTIES						
Brinell Hardness	250	400–800	—	50–150	5	—
Abrasion Resistance[a]	Good	Excellent	—	Poor	Poor	—
CORROSION RESISTANCE, 10^{-6} ipy						
Atmosphere	—	—	—	—	72–320	—
Sea Water	—	—	—	40	30–90	—
SOLDERABILITY						
As Plated	—	—	—	—	Good	—
After 192-Hr Salt Spray	—	—	—	—	Poor	—
COST	—	Moderate	—	High	Moderate	—
USES[b]	d	c, D	Rectifiers	C, D, e, w	Experimental	Experimental

[a] Even though some electroplates abrade easily they may still have excellent appearance (e.g., gold and silver), or may even provide an excellent bearing surface (e.g., indium, silver and lead).
[b] Capital letter indicates frequent use, small letter infrequent. C = corrosion protection; D = decoration; E = electroforming; R = reclaiming; W = wear resistance.

continued on next page

Electrodeposited Coatings

Type →	Tungsten	Zinc	Zirconium	Cobalt-Nickel	Copper-Tin (bronze)	Copper-Zinc (brass)
BASE METALS	(experimental)	Ferrous metals	(experimental)	(experimental)	Steel, copper, brass, zinc	Iron, steel, aluminum, zinc
PHYSICAL PROPERTIES						
Ther Cond, Btu/hr/sq ft/°F/ft	84.7	64.2	—	—	—	—
Elec Res, microhm-cm	5.5	5.8	41	—	—	—
Color (natural)	Gray	White (bright)	—	Gray	Pink (bright)	Yellow (bright)
Reflectance When Polished (5000 A), %	0.49	55	—	—	—	—
Melting Point, F	6098	786	3452	—	—	—
Min Thickness, mil	—	0.15	—	—	0.5	0.1
MECHANICAL PROPERTIES						
Brinell Hardness	—	40–50	—	—	—	—
Abrasion Resistance[a]	—	Fair	—	Good	Good	Fair
CORROSION RESISTANCE, 10^{-6} ipy						
Atmosphere	—	8–210	—	—	—	—
Sea Water	—	1000–6000	—	—	—	—
SOLDERABILITY						
As Plated	Good	—	—	—	—	—
After 192-Hr Salt Spray	Poor	—	—	—	—	—
COST	—	Low	—	—	Moderate	Moderate
USES[b]	Experimental	C, d	Experimental	Magnetic	c, D, w	c, D

Type →	Lead-Tin	Nickel-Tin	Phosphorus-Nickel-Cobalt	Tin-Zinc	Tungsten-Nickel-Cobalt-Iron
BASE METALS	Steel, copper, brass	Most ferrous and nonferrous metals	—	Most ferrous and nonferrous metals	—
PHYSICAL PROPERTIES					
Ther Cond, Btu/hr/sq ft/°F/ft	—	—	—	—	—
Elec Res, microhm-cm	—	—	110–118	—	—
Color (natural)	White	White (bright)	Bluish (bright)	White	Gray
Reflectance When Polished (5000 A), %	—	15–118	—	—	—
Melting Point, F	—	—	—	—	—
Min Thickness, mil	0.2	0.5	—	0.15	—
MECHANICAL PROPERTIES					
Brinell Hardness	—	625 (Vickers)	—	—	—
Abrasion Resistance[a]	Poor	Good	—	Good	—
CORROSION RESISTANCE, 10^{-6} ipy					
Atmosphere	—	—	—	—	—
Sea Water	—	—	—	—	—
SOLDERABILITY					
As Plated	Good	—	—	Good	—
After 192-Hr Salt Spray	—	—	—	Poor	—
COST	Moderate	Moderate	—	Moderate	—
USES[b]	c, w	C, D	C, d, e, w	C	C, e, r, w

[a] Even though some electroplates abrade easily they may still have excellent appearance (e.g., gold and silver), or may even provide an excellent bearing surface (e.g., indium, silver and lead).
[b] Capital letter indicates frequent use, smaller letter infrequent. C = corrosion protection; D = decoration; E = electroforming; R = reclaiming; W = wear resistance.

Sprayed Metal Coatings

Type →	Aluminum	Babbitt A[a]	Brass (65:35)	Bronze AA[b]	Commercial Bronze	Manganese Bronze	Phosphor Bronze
Specific Gravity	2.41	6.67	7.45	7.06	7.57	7.26	7.68
Ult Ten Str, 1000 psi	19.5	—	12	29	11.5	12	18
Strain at Ult Str, %	0.23	—	0.45	0.46	0.42	0.46	0.35
Rockwell Hardness	H72	H58	B22	B78	B18	B27	B20
Shrinkage, in./in.	0.0068	—	0.009	0.0055	0.011	0.009	0.010
Spraying Speed, lb/hr	18	95	32	24	24	36	31
Spraying Efficiency, %[c]	89	69	81	77	82	79	85
Major Characteristics and Uses[d]	Good corrosion and heat resistance	Good bearing properties	Sprays fast. Fair machine finish	Hard, very wear resistant. Easily machined	Softest bronze. Fair machine finish	Excellent machine finish. Special uses only	Fair machine finish. Special uses only

[a]Lead-free, high tin alloy. [b]Aluminum-iron-bronze. [c]Percent of metal deposited.
[d]All metals have about the same shiny surface after spraying, but surfaces of the various metals differ after machining.

Type →	Tobin Bronze	Copper	Lead	Molybdenum	Monel	Nickel	18-8 Stainless
Specific Gravity	7.46	7.54	10.21	8.86	7.67	7.55	6.93
Ult Ten Str, psi	13	—	—	7.5	21	17.5	30
Strain at Ult Str, %	0.51	—	—	0.30	0.26	0.30	0.27
Rockwell Hardness	B27	B32	—	C38	B39	B49	B78
Shrinkage, in./in.	0.0104	—	—	0.003	0.009	0.008	0.012
Spraying Speed, lb/hr	36	29	80	8	17	18	21
Spraying Efficiency, %[c]	80	80	65	87	85	79	81
Major Characteristics and Uses[d]	General purpose. Fair machine finish	Electrical uses; brazing	Good corrosion resistance. X-ray shielding	Used as bonding coat. Excellent bearing properties	Good corrosion resistance. Good machine finish	Good corrosion resistance. Fair machine finish	High corrosion resistance. Good wearing properties

Type →	High Cr Stainless	Steel (LS)[e]	Steel (0.10% C)	Steel (0.25% C)	Steel (0.80% C)	Tin	Zinc
Specific Gravity	6.74	6.78	6.67	6.78	6.36	6.43	6.36
Ult Ten Str, psi	40	33.5	30	34.7	27.5	—	13
Strain at Ult Str, %	0.50	0.54	0.30	0.46	0.42	—	1.43
Rockwell Hardness	C29	C25	B89	B90	C36	—	H46
Shrinkage, in./in.	0.0018	0.002	0.008	0.006	0.0014	—	0.010
Spraying Speed, lb/hr	19	18	19	19	19	95	61
Spraying Efficiency, %[c]	81	87	87	87	87	73	66
Major Characteristics and Uses[d]	High hardness and wear resistance. Grind finish	Good mechanical and finishing properties	Simple bearing surfaces and press fits. Excellent machine finish	Harder and lower shrinkage than 0.10C. Excellent machine finish	Very hard and wear resistant. Good bearing properties. Grind finish	Good corrosion resistance, especially with foods	Good all-around corrosion resistance

[e]Low shrinkage.

Hot Dip Coatings[a]

Type ➔	**Aluminum** (aluminized)	**Zinc** (galvanized)	**Lead**	**Tin**	**Lead-Tin** (terne)
Base Metals	Steel	Steel	Steel and copper	Steel or copper	Steel
Thickness	Most commonly applied in thicknesses of 1 to 2 mils	For structural steel shapes, plates and bars, weight of coating should be 2 oz per sq ft	8–40 lb per double base box	Sheet: 1.25–4.0 lb per double base box. Wire, strip: 0.005 mil. Fabricated parts: 0.3–0.5 mil	8–40 lb per double base box
Important Properties	Combines corrosion res and heat reflectivity of aluminum with mechanical and physical properties of steel; withstands up to 900 F without discoloring and up to 1250 F without descaling; in some cases can be used up to 1650 F	Combines high corrosion res with low cost; has slower corrosion rate than iron; corrosion products are white and nonstaining; provides electrolytic protection to iron	Major advantage is high res to atmospheric corrosion and chemicals, especially sulfuric and hydrochloric acids, and brine; superficial protective oxide film regenerates itself when damaged; can withstand severe deformation	Very good res to tarnishing and staining indoors, pure rural atmospheres, and food; sheet can be severely deformed without damage (lends itself to stamping, drawing, rolling, lock-seaming and bending); sheet is readily soldered	Provides some of the advantages of tin coatings at lower cost; ductility and good adhesion allow deep drawing; excellent paint-holding properties
Limitations	Above 900 F, coating begins to alloy with base metal to form refractory layer which will not return to original state	Life of coatings is about five to ten times greater in rural than in industrial atmospheres containing sulfur and acid gases	Poor res to wear and abrasion; poor adhesion; pinholes may form during application; performs better in industrial than rural atmospheres	Presence of many minute pores causes accelerated corrosion, especially in wet environments; res to marine and industrial atmospheres not very good	Provides only mechanical protection against corrosion
Remarks	Corrosion res is often superior to that of galvanized steel, but aluminum coating is more expensive	Greater protection can be obtained by increasing thickness	Adhesion can be improved by adding small quantities of alloying ingredients; pinholes can be eliminated by slight working or burnishing	Corrosion res markedly improved by increasing thickness and controlling porosity	Corrosion res can be improved greatly by using organic coatings
Uses	High temp applications such as fire walls, water heater and oven liners, mufflers, heat exchanger tubes, space heater parts, combustion chambers	Roofing and siding, nails, wire, tanks, boilers, pails, and wide range of hardware for indoor and outdoor use	Wire, pole-line hardware, bolts, washers, tanks, barrels, cans, air ducts. Good adhesion of organic coatings has proved valuable for such outdoor uses as gutters, flashing and corrugated siding	Hot dipped tin coatings on food cans have largely been superseded by tin electroplates; however, the heavier coatings produced by hot dipping are useful for some fabricated parts and castings	If used in sufficient thickness, coatings provide good protection for such things as gasoline tanks and roofing, and benches and cabinets used in chemical laboratories

[a] For all types except terne, two layers are formed on the base metal: the outer layer is generally relatively pure coating metal, the intermediate layer is an alloy of the coating metal and the base metal. Terne coatings generally contain 10–25% tin and 75–90% lead.

Immersion Coatings

Type →	Electroless Nickel	Tin	Copper	Gold	Silver
Base Metals	Most ferrous and nonferrous metals	Copper, brass, bronze, aluminum, steel	Steel, brass, aluminum and printed circuit boards	Most ferrous and nonferrous metals	Most metals except lead, zinc, aluminum and other very active metals; copper, nickel and stee best
Thickness	From 1 to 5 mils, depending on end use	Decorative: 0.015 mil; heavy duty: up to 2 mils	From 0.1 to 1 mil	Usually about 0.001 mil	Usually about 0.001 mil, but sometimes as high as 0.03 mil
Important Properties	Because of their amorphous structure and phosphorus content (8–10%), these coatings have better abrasion resistance than electrolytic or wrought nickel; hardness is relatively high (about R_c 50, which can be heat treated to R_c 64)	Combines bright appearance, good frictional properties and ease of application with low cost	High electrical conductivity, good lubrication properties	Good electrical conductivity and emissivity; bright, attractive appearance	Bright, attractive appearance
Limitations	Generally more expensive than electroplated nickel	Corrosion resistance is only fair; plating usually stops when base metal is covered	Not especially noted for decorative appeal	Poor resistance to discoloration and abrasion	Poor resistance to tarnishing and abrasion
Remarks	Although coating is used primarily for functional properties, a smooth, bright deposit can be obtained with buffed metals	Heavier coatings can be produced by placing base metal in contact with a dissimilar metal, thereby generating an electric current and promoting additional plating	Unusual appearance can be used to advantage for such things as inexpensive hardware and casket parts	Relatively inexpensive due to extreme thinness; discoloration and abrasion resistance can be improved with a clear lacquer finish	Relatively inexpensive due to extreme thinness; can be protected somewhat against tarnishing with a clear lacquer finish
Uses	Protecting parts from corrosion and preventing product contamination. Tank car interiors, oil refinery air compressors, missile fuel injector plates, pumps, reciprocating surfaces; aluminum electronic devices (to facilitate soldering); stainless steel (to facilitate brazing)	Decorative finishing of small parts such as safety pins, thimbles and buckles; also used on copper tubing to prevent discoloration from water and on aluminum engine pins to provide lubrication during break-in periods	Because of their conductivity, these coatings have proved particularly useful for printed circuits. Because of their good lubrication properties, they are also used on steel wire in die forming operations	Principally used on costume jewelry, trophies, auto trim and many inexpensive novelties. Their conductivity and solderability have proved useful in electrical applications such as printed circuits, transistors and connectors. Emissivity properties valuable in some missile applications	Cheap decorative products, minor electronic parts and maintenance plating

Diffusion Coatings*

Type →	Galorized	Carburized	Chromized	Cyanided, Carbonitrided
Base Metals	Carbon, low alloy steels	Carbon and alloy steels low enough in carbon content (<0.45%) to take up that element readily	Low and high carbon steels, many alloy steels, stainless steels, tool steels, cast iron, iron powder parts	Same steels as used for carburizing
How Applied	Aluminum introduced into surface by treating metal in powdered aluminum compound or aluminum chloride vapor, or by spraying and subsequently heat treating; alloy coating (5–40 mils) contains about 25% aluminum	Carbon introduced into surface by heating solid, liquid or gaseous carbon in contact with base metal at temperatures above the transformation range, generally 1450–1750 F	Chromium introduced into surface by heating metal in contact with a chromium-containing powdered compound at 1500–1900 F. High chromium-iron alloy is formed on low-carbon ferrous metals (3 mils); chromium carbide case is formed on high carbon metals (½–2 mils)	Carbon and nitrogen introduced into surface by heating metal in a liquid cyanide bath (cyaniding) or in a carbonaceous and nitrogeneous (carbonitriding) bath, the temperature ranging from 1200–1600 F
Important Properties	Resistance to high temperature oxidation (long time service at temperatures up to 1400 F); protects by sealing metal from surrounding air	High strength and toughness in core can be combined with extreme surface hardness; plain carbon steels are used if core properties are not too critical; alloy steels are used if strength and toughness are needed in core	High resistance to wear, abrasion and corrosion; high hardness (1600–1800 VPN)	Hard and wear resistant surface; warping is less serious than in carburizing; quenching is usually necessary for full hardness
Uses	Chemical and metal process pots, bolts, air heater tubes, and parts for furnaces and steam superheaters	Gears, cams, pawls, racks and shafts	Aircraft, railroad and automotive parts, combustion equipment, mechanical equipment, tools, heating apparatus	In general, same as carburized

Type →	Nickel-Phosphorus	Nitrided	Sherardized	Siliconized
Base Metals	Ferrous metals	Primarily special nitriding steels. Also medium carbon steels containing chromium and molybdenum, stainless steels, some cast irons	Ferrous and nonferrous metals	Low carbon (<0.25%), low sulfur (<0.04%) steels
How Applied	Nickel-phosphorus introduced into surface by painting metal with mixture of nickel oxide, dibasic ammonium phosphate and water, and then heating	Nitrogen introduced into surface by heating metal in contact with ammonia or other nitrogeneous material, the temperature ranging from 930–1050 F	Zinc introduced into surface by heating base metal in a zinc powder for 3–12 hr at 650–750 F	Silicon introduced into surface by heating metal in contact with silicon carbide and chlorine at 1700–1850 F
Important Properties	Corrosion resistance approaches that of stainless steel and high nickel alloys; must be heat treated in controlled atmosphere; little porosity; poor resistance to heat and abrasion	High wear resistance, retention of hardness at elevated temperatures; good resistance to certain types of corrosion; produces minimum distortion	Improves corrosion resistance; coatings are not as protective as plated or hot dipped zinc coatings, but are more uniform	High resistance to wear, heat and corrosion; improves hardness; surfaces are nongalling; case (5–10 mils) is brittle
Uses	Pipe and fittings	In general, same as carburized	Small steel parts such as nuts, bolts, and washers, or castings that must resist atmospheric corrosion	Pump shafts; cylinder liners; valves, valve guides and fittings; conveyor chain links

* Surface alloying treatments for metals.

Vapor Deposited Coatings

Type ➜	Vacuum Metallized	Cathode Sputtered	Vapor Plated
Coating Metals	Primarily aluminum; also cadmium and selenium	Primarily gold and silver; also platinum and palladium; in general, any low-vapor-pressure metal	Primarily nickel; also iron, chromium, cobalt, molybdenum and some precious metals
Base Materials	Primarily zinc, steel, plastics; also aluminum, glass, paper	Most metals and nonmetallics	Most metals and nonmetallics
How Applied	Evaporation—Metal is brought in contact with hot filament (tungsten, molybdenum or platinum) in a vacuum of at least 10^{-4} mm of Hg; the metal evaporates (in 5-15 sec) and condenses on all cool surfaces that lie in straight path from filament	Ion bombardment—A high voltage (10,000 v or more) is applied across two electrodes; ion bombardment vaporizes the cathodic metal and deposits it as a crystalline, fine-grained coating on material placed near anode	Thermal decomposition ("gas plating")—Metal to be deposited must exist in the form of a gaseous compound that decomposes at a temperature higher than its vaporization temperature; part to be plated is heated above this decomposition temperature of the compound and inserted in the plating chamber
Important Properties	Deposition rates are slow; process is expensive compared to electroplating unless restricted to large runs of small or medium-sized parts and to thin coatings. For thin films (0.003 to 0.005 mil), vacuum metallizing is best method—it is low cost and produces finely controlled and uniform deposits which closely follow contours of base surface. Abrasion resistance is generally low. Corrosion resistance very good for cadmium coated parts	Lower vacuum is required than in vacuum metallizing (only 0.01-0.1 mm Hg) and hence less expensive equipment, but deposition rates are slower, and some metals, including aluminum, cannot be deposited. Thin films are generally highly porous, but deposits of 0.04 mil are satisfactory. Temperature rise producedi n substrate is often higher than in vacuum metallizing. It is difficult to avoid oxide contamination	Method is adaptable to odd-shaped objects, deposits coatings with greater speed than any conventional plating process, makes possible the deposition of alloys, and is applicable to porous surfaces such as powder metal parts. Gaseous compounds are expensive and, in some cases, toxic
Uses	Aluminum-coated zinc or steel—hardware, costume jewelry, optical reflectors, instrument parts, automotive trim and interior hardware; selenium-coated nickel-plated aluminum—selenium rectifiers; aluminum-coated plastics—automotive interior hardware, panels, dials and trim; aluminum-coated glass—electroluminescent panels	Phonograph recording masters, surgical gauze, broadcasting transmitters, and jewelry	Thick coatings of refractory metals on wires; nickel-coated gasoline fuel delivery nozzles; and the previously impossible metallic coating of nylon and glass fibers

Organic Coatings[a]

Type →	Alkyd						Acrylic	Bituminous
	Alkyd	Alkyd-Amine	Alkyd-Phenolic	Alkyd-Silicone	Alkyd-Urea	Styrenated Alkyd		
CHEMICAL RESISTANCE								
Exterior Durability	E	E	E	E	E	G	E	E
Salt Spray	E	VG	E	E	G	G	E	E
Solvents—Alcohols	F	G	G	F	G	G	G	P
Solvents—Gasoline	G	E	E	E	E	E	G	P
Solvents—Hydrocarbons	G	E	E	P	E	F	F	P
Solvents—Esters, Ketones	P	P	F	P	P	P	P	P
Solvents—Chlorinated	P	P	F	P	P	P	P	P
Beverages, Food	F	G	VG	P	G	VG	VG	E
Salts	VG	E	E	F	E	E	VG	G
Ammonia	P	P	P	P	P	P	P	—
Alkalis[b]	G, G	VG, G	F, P	P, P	G, G	G, VG	G, F	E
Acids—Mineral[c]	F, P, P	G, F, P	VG, G, F	G, P, P	F, P, P	G, F, P	G, F, P	G, —, —[j]
Acids—Oxidizing[c]	P, P, P	F, P, P	G, F, P	P, P, P	F, P, P	F, P, P	F, P, P	—
Acids—Organic (acetic, formic, etc.)[c]	P, P, P	P, P, P	F, P, P	P, P, P	P, P, P	P, P, P	P, P, P	E, —, —[k]
Acids—Organic (oleic, stearic, etc.)	F	G	VG	G	F	F	F	E
Acid—Phosphoric	P	P	P	P	P	P	P	E
Water (salt, fresh)	F	G	E	E	F	G	E	E
PHYSICAL PROPERTIES								
Sward Rocker Hard. (8th day)	24	30	34	16	28	28	24	—
Flexibility	E	VG	G	F	VG	G	E	E
Abrasion Res, cycles[d]	3500	>5000	>5000	1000	>5000	>5000	2500	—
Max Svc Temp, F	200	250	250	1000	225	200	180	325
Toxicity	None	Slight	None	Slight	Slight	Slight	None	—
Impact Res	VG	E	G	G	E	G	E	E
Dielec Properties	G	G	VG	E	G	G	VG	—
Adhesion to—								
Ferrous Metals	E	E	E	G	E	E	VG	E
Nonferrous Metals	F	E	E	F	VG	E	VG	E
Old Paints	VG	G	G	E	G	VG	P	—
DECORATIVE PROPERTIES								
Choice of Colors[e]	U	U	SL	U	U	U	U	L
Color Retention	G[f]	VG[f]	P[f]	E[f]	VG[f]	G[f]	E[f]	—
Initial Gloss	E	E	VG	E	E	E	E	P
Gloss Retention	E	G	F	E	F	G	E	—
APPLICATION								
Ease of Application	E	Bake req	E	E	Bake req	E	VG	P–VG
Metal Surface Prep	Primer	No primer	No primer	Primer	No primer	No primer	Primer	No primer
Solvent for Appl[g]	Hyd	Hyd	Hyd	Hyd	Hyd	Hyd	Blend	—
Methods[e]	U	U	U	U	U	U	U	L
Cure[h]	A or B	B	A or B	A or B	B	A or B	A	A
Bake Drying Time[i]	30 min (275 F)	20 min (320 F)	30 min (350 F)	30 min (350 F)	20 min (320 F)	15 min (300 F)	—	—
Air Drying Times								
Touch	2 hr	—	20 min	45 min	—	10 min	5 min	2 hr
Handle	4 hr	—	60 min	2 hr	—	30 min	15 min	24 hr
Re-Coat	4 hr	—	6 hr	4–6 hr	—	4 hr	15 min	—
Hard	12 hr	—	6 hr	12 hr	—	4 hr	12 hr	24 hr
Corr Res	48 hr	—	48 hr	12 hr	—	48 hr	24 hr	—
Coverage, sq ft/gal/mil	450	450	450	500	450	400	350	—
Coat Thk (avg), mil	1.5	1.5	1.5	0.6	1.5	1.5	1.0	3–250
Cost, ¢/sq ft/mil dry[l]	1.50	1.75	—	—	—	1.75	2.75	—

[a] These data are intended only as a preliminary selection guide. Final selections should be made after consulting with coating formulator. Key: E = excellent; VG = very good; G = good; F = fair; P = poor

[b] Two ratings are for dilute (20%) and concentrated, respectively.

[c] Three ratings are for dilute (10%), medium (10–30%) and concentrated, respectively.

[d] Taber GS-10 wheel.

[e] L = limited (pure white cannot be formulated): SL = slightly limited (difficulty in formulating whites and pastels); U = unlimited (any color can be formulated).

Notes [f] through [l] on opposite page.

Organic Coatings [a]

Type →	Cellulose		Epoxy						Fluoro-carbon (air dried)
	Nitro-cellulose	Butyrate	Epoxy (100%)	Epoxy-Amine	Epoxy-Ester	Epoxy-Melamine	Epoxy-Phenolic	Epoxy-Urea	
CHEMICAL RESISTANCE									
Exterior Durability	E	E	G	E	G	E	E	G	E
Salt Spray	E	E	E	VG	E	VG	VG	VG	E
Solvents—Alcohols	G	G	E	E	VG	E	E	E	F
Solvents—Gasoline	G	G	E	E	E	E	E	E	F
Solvents—Hydrocarbons	F	F	E	E	VG	E	E	E	P
Solvents—Esters, Ketones	P	P	F	VG	F	VG	E	VG	P
Solvents—Chlorinated	P	P	E	E	F	E	E	E	P
Beverages, Food	P	G	E	E	VG	E	E	E	E
Salts	G	VG	E	E	E	E	E	E	E
Ammonia	P	P	P	P	P	P	VG	P	E
Alkalis[b]	P, P	P, P	E, E	E, E	E, E	E, E	E, E	E, E	E, E
Acids—Mineral[c]	G, F, P	G, F, P	E, VG, G	E, VG, G	G, F, P	E, VG, G	E, E, E	E, VG, F	E, E, E
Acids—Oxidizing[c]	P, P, P	P, P, P	G, P, P	G, P, P	F, P, P	G, P, P	E, VG, P	F, P, P	E, E, E
Acids—Organic (acetic, formic, etc.)[c]	P, P, P	P, P, P	G, F, P	G, F, P	F, P, P	G, F, P	E, E, VG	F, P, P	E, E, E
Acids—Organic (oleic, stearic, etc.)	F	F	E	E	E	E	E	E	E
Acid—Phosphoric	P	P	P	P	P	P	E	P	E
Water (salt, fresh)	F	E	VG	G	VG	G	E	G	E
PHYSICAL PROPERTIES									
Sward Rocker Hard. (8th day)	26	26	36	36	30	36	44	34	20
Flexibility	E	E	E	G	G	VG	VG, E	VG	G
Abrasion Res, cycles[d]	2500	2500	>5000	>5000	>5000	>5000	>5000	>5000	1000
Max Svc Temp, F	180	180	400	400	300	400	400	400	—
Toxicity	None	None	Slight	Slight	Slight	Slight	Slight	Slight	Slight
Impact Res	E	E	G	G	E	G	G	G	E
Dielec Properties	P	G	VG	VG	VG	VG	VG	VG	E
Adhesion to—									
Ferrous Metals	VG	VG	E	E	E	E	E	E	VG
Nonferrous Metals	G	G	E	E	VG	E	E	E	VG
Old Paints	P	P	P	P	F	P	P	P	P
DECORATIVE PROPERTIES									
Choice of Colors[e]	U	U	SL	SL	SL	SL	L	SL	U
Color Retention	E[f]	E[f]	G[f]	G[f]	E[f]	G[f]	P[f]	G[f]	G
Initial Gloss	E	E	VG	VG	E	VG	VG	VG	E
Gloss Retention	VG	E	F	F	G	F	F	F	F
APPLICATION									
Ease of Application	VG	VG	Catalyst req	Catalyst req	E	Bake req	Bake req	Bake req	VG
Metal Surface Prep	Primer	Primer	No primer	No primer	Primer	No primer	No primer	No primer	Primer
Solvent for Appl[g]	Blend	Blend	Ketone	Blend	Hyd	Blend	Blend	Blend	Blend
Methods[e]	U	U	L	L	U	L	L	L	L
Cure[h]	A	A	A	A	A or B	B	B	B	A or B
Bake Drying Time[i]	—	—	—	—	30 min (320 F)	30 min (350 F)	30 min (400 F)	30 min (350 F)	—
Air Drying Times									
Touch	5 min	5 min	45 min	45 min	1 hr	—	—	—	5 min
Handle	15 min	15 min	2 hr	2 hr	2 hr	—	—	—	15 min
Re-Coat	15 min	15 min	6–8 hr	6–8 hr	8 hr	—	—	—	12 hr
Hard	12 hr	12 hr	12 hr	12 hr	8 hr	—	—	—	12 hr
Corr Res	24 hr	24 hr	7–10 days	7–10 days	5 days	—	—	—	12 hr
Coverage, sq ft/gal/mil	200	200	450	500	450	500	450	500	200
Coat Thk (avg), mil	1.0	1.0	1.8	1.8	1.5	1.8	1.8	1.8	1.0
Cost, ¢/sq ft/mil dry[l]	2.50	2.75	—	—	1.75	—	—	2.00	15.00

Notes [a] through [e] on opposite page.
[f] Based on white coatings with titanium dioxide pigment. [g] Hyd = hydrocarbons; alc = alcohols.
[h] A = can be air dried; B = can be baked. In general, any coating that can be air dried or baked will perform better if baked.
[i] Full corrosion resistance is obtained, immediately upon cooling. [j] Not recommended with nitric acid.
[k] Not recommended with strong solutions of acetic acid.
[l] Based on high quality formulations; figures are meant to serve only as a rough guide.

continued on next page

Organic Coatings [a]

Type ➡	Phenolic	Poly-amide (nylon)	Rubber: Chlorinated Rubber	Rubber: Neoprene	Rubber: Hypalon	Silicone	Urethane	Vinyl	Vinyl-Alkyd (approx 1:1)
CHEMICAL RESISTANCE									
Exterior Durability	E	P	E	E	E	E	E	E	E
Salt Spray	E	F	E	E	E	E	E	E	E
Solvents—Alcohols	E	G	F	E	—	P	F–G	E	G
Solvents—Gasoline	E	G	G	F	P	VG	F–G	E	E
Solvents—Hydrocarbons	E	—	P	P	—	VG	F–E	G	P
Solvents—Esters, Ketones	E	—	P	G	—	P	F	P	P
Solvents—Chlorinated	G	—	P	P	—	P	P	P	P
Beverages, Food	E	—	G	F	—	P	VG	E	F
Salts	E	—	E	E	—	G	E	E	G
Ammonia	P	G	VG	E	E	P	P	E	P
Alkalis[b]	P, P	G, G	VG, F	E, E	—	P, P	VG, F	E, E	G, P
Acids—Mineral[c]	E, E, E	P, P, P	E, G, P	E, G, P[k]	E, E, E	G, P, P	G, F, P	E, E, G	VG, G, P
Acids—Oxidizing[c]	E, E, VG	—	E, E, P	G, F, P	—	P, P, P	G, F, P	E, VG, G	P, P, P
Acids—Organic (acetic, formic, etc.)[c]	G, F, P	P, P, P	G, P, P	P, P, P	—	P, P, P	G, F, P	E, P, P	G, F, P
Acids—Organic (oleic, stearic, etc.)	E	VG	E	F	—	P	F	E	E
Acid—Phosphoric	F	—	G	VG	E	P	F	E	F
Water (salt, fresh)	E	F	VG	E	E	E	E	E	E
PHYSICAL PROPERTIES									
Sward Rocker Hard. (8th day)	38	—	24	<10	—	16	35–65	20	26
Flexibility	G	G	VG	E	E	F	E	E	E
Abrasion Res, cycles[d]	>5000	—	>5000	5000	—	2500	>5000	>5000	2500
Max Svc Temp, F	350	300	250	200	250	1200	300	180	180
Toxicity	None	—	Slight	None	—	Slight	Slight	None	None
Impact Res	G	VG	G	E	E	G	E	E	E
Dielec Properties	E	G	E	F	VG	E	E	E	G
Adhesion to—									
Ferrous Metals	E	VG	F	VG	VG	G	E	VG	VG
Nonferrous Metals	E	VG	VG	VG	VG	F	E	VG	G
Old Paints	G	—	E	—	—	E	F	G	P
DECORATIVE PROPERTIES									
Choice of Colors[e]	L	L	L	L	U	U	U	U	U
Color Retention	P[f]	—	G[f]	G	E	G[f]	G	VG[f]	E[f]
Initial Gloss	VG	G	F	P	P	E	E	G	E
Gloss Retention	F	—	F	F	—	E	P	F	E
APPLICATION									
Ease of Application	E	G	E	VG	VG	E	E	VG	VG
Metal Surface Prep	No primer	No primer	Primer	No primer	No primer	Primer	Primer	Primer	Primer
Solvent for Appl[g]	Alc	—	Hyd	Hyd	Hyd	Hyd	Blend	Blend	Blend
Methods[e]	U	L	U	U	U	U	U	L	U
Cure[h]	A or B	A	A or B	A or B	A	A or B	A or B	A or B	A
Bake Drying Time[i]	30 min (350 F)	—	15 min (300 F)	15 min (300 F)	—	1 hr (400 F)	30 min (325 F)	15 min (300 F)	—
Air Drying Times									
Touch	10 min	—	45 min	15 min	15 min	45 min	45 min	15 min	5 min
Handle	30 min	—	2 hr	30 min	30 min	2 hr	1–2 hr	30 min	15 min
Re-Coat	30 min	—	4–6 hr	4 hr	4 hr	4–6 hr	4–6 hr	4–6 hr	15 min
Hard	4 hr	—	4–6 hr	4 hr	4 hr	12 hr	18 hr	4–6 hr	12 hr
Corr Res	24 hr	—	24 hr	7–10 days	7–10 days	12 hr	5–7 days	24 hr	24 hr
Coverage, sq ft/gal/mil	350	—	450	300–400	250–350	350	—	250	200
Coat Thk (avg), mil	1.5	2–30	1.5	2–10	2	1.0	1–2	1.0	1.0
Cost, ¢/sq ft/mil dry[j]	1.75	—	1.50	—	—	6.00	—	2.50	—

Notes: See previous two pages.

Hard Facings

Hard facings (overlays applied by welding operations) are generally applied to surfaces which require high wear resistance. Service conditions which may be met, directly or indirectly, by hard facing include: abrasion (sliding or rolling), galling, impact, work hardening, elevated temperatures, thermal stresses, corrosion and erosion.

Types. Most hard facing alloys are proprietary alloys designed for special service conditions, but the basic types are summarized below. It can be misleading to group alloys by hardness or service use because it is primarily structure that determines their properties. Iron-base alloys, for example, can be austenitic, pearlitic, martensitic or a combination of these in the as-deposited, air cooled state. It is often difficult to determine what microstructure can be expected from a given rod.

Thickness. Thickness of hard facings ranges from 1/16 to ¼ in. depending upon the application. Parts that require a build-up greater than ¼ in. are usually given a primary layer with a lower cost material. Parts requiring extremely thin layers are generally hard faced with nickel-chomium-boron alloys which wet the base metal so readily that a uniform deposit 1/32 in. thick can be obtained.

Surface finish. Smoothness of a hard facing depends upon both material and application method. Nonferrous alloys, having more fluidity, yield the smoother deposits. Tungsten carbide rods produce a rough surface because the particles must be submerged in a matrix of softer material which wears away and exposes the rough carbide particles.

BASIS METALS FOR HARD FACING

Metal ↓	Suitability	Remarks
Low and Medium Carbon Steels	Up to 0.50 carbon steels particularly suitable	Pre- or post-heat treatment not required
High Carbon and Low Alloy Steels	Up to 1.10 carbon and 14 manganese steels are suitable if careful to prevent cracking	Annealed or as-rolled condition; generally post-heat treated
High Speed Steels	Not advisable; shrinkage cracks, strain checks	Annealed condition; post-heated and slowly cooled
High Chromium Steels	Susceptible to heat; require careful handling	Preheated to 1200 F; slow post-cooling
Manganese Steels	Difficult, due to heat disrupting grain structure. Arc welding best	Stainless steel often applied first as binding agent
Stainless Steels	Arc or gas method with care to avoid excessive strains	Parts should be preheated to temperature dependent on stainless type
Cast Irons	Difficult. White iron easy for small parts. Otherwise danger of localized overheating	Lower melting point than steel; crust forms on surface
Nonferrous Alloys	Not those with melting points below 2000 F	Monel is common and easiest; copper alloys difficult

TYPES OF HARD FACING ALLOYS

Type →	General Properties	Forms	How Applied	Typical Uses
FERROUS ALLOYS				
Hardenable. Carbon steels; low, medium and high alloy steels; high speed steels	Alloys are listed in order of increasing hardness, corrosion and impact resistance. Medium-high levels of hardness and impact resistance obtainable, but abrasion and corrosion resistance lower than in other types	Mild steel rod with alloys in flux-coating; particles in thin tubes	Arc welding (bare and flux-coated rods) or gas welding (bare rods)	Base for subsequent hard facing with other types (particularly for thick facings); rock and earth-handling equipment
Austenitic. Chromium and chromium-nickel steels; high manganese steels; high chromium irons; high alloy irons	Provide principally austenitic deposits (except some straight chromium steels) hardenable by cold work. Fair degree of hardness with good impact and abrasion resistance extending inlo elevated temperatures	Cast rods	Arc welding (bare and flux-coated rods) or gas welding (bare rods)	Crushing equipment; such earth-moving equipment as bucket lips, crusher rolls and muller tires; plowshares
NONFERROUS ALLOYS				
Cobalt-base. Medium carbon; high carbon	High corrosion resistance, good abrasion and impact resistance. Hardness less than high ferrous alloys but retained at elevated temperatures ("red hardness")	Solid rods cast in permanent or sand molds	Gas welding (use of torch is similar to brazing)	Valves, pump parts, dies; large areas where hairline cracks not permissible
Nickel-base. Nickel-chromium; nickel-chromium-tungsten molybdenum	Excellent heat and corrosion resistance, fair abrasion and impact resistance. Hardness is less than high ferrous alloys but retained at elevated temperatures ("red hardness")	Solid rods cast in permanent or sand molds	Gas welding (use of torch is similar to brazing)	Very thin sections; parts which must be hot formed or hot wiped; substitute for tungsten carbide rods
Intermetallics. Tungsten carbides; others	Maximum hardness with excellent resistance to impact and corrosion. Despite brittleness, carbides have excellent resistance to fracture when backed up with steel.	Cast rod; particles in thin tube; powder; inserts	Rods by gas or arc; powder by spraying; inserts by "puddling"	Oil well drilling tools; mill hammers, augers, dipper bucket teeth and lips, mixing plows

Ceramic, Cermet and Refractory Coatings

Type	Important Properties
Mixtures of Porcelain Enamel Frits and Refractory Materials	
NBS[a] A-19	Prevents oxidation of noncritical steels at high temp. Protects low carbon steel to 1250 F and high temp austenitic alloys to 1550 F
NBS A-31	Similar to A-19 coating but, since it must be applied in two coats, is only used for specialized applications
NBS A-417	Protects noncritical steels against high temp oxidation. Has been largely supplanted by A-418 coating
NBS A-418	Widely used to extend life of heat resisting steels such as Inconel, Inconel X, Nimonic 75, HS-21 and 18-8, 19-9 and 25-20 stainless steels. Protects up to 1750 F. Not recommended for low carbon steels
NBS N-143	Has low absorption coefficient for thermal neutrons and is designed for nuclear applications. Protects 310 stainless, Nichrome V and Inconel against oxidation up to 2050 F
Proprietary Coatings for:[b]	
Low Carbon and Low Alloy Steels	Improves oxidation and corrosion resistance to 1400 F
300 and 400 Stainless Steels	Extends service life of most alloys up to 1800 F. Special formulations protect against unusual abrasive or corrosive attack up to 2000 F
Aluminum	Extends operating temp of standard and some high strength alloys up to 1550 F
Titanium	Allows use of titanium up to 1500 F
Thin-Gage Metals	Protects foils 1 to 10 mils thick at temp up to 1750 F. Used on 300 and 400 stainless steels and superalloys
Extra High Temperatures	Special coatings for use up to 2100 F. Can be used on all alloys containing 45% of the combination of chromium (10% min), cobalt and nickel
Resistance to Galling	Provides low friction and prevents galling at temp from 800 to 1650 F. Can be used on all ferrous (and some nonferrous) alloys
Pure Refractory Oxide Coatings	
Aluminum Oxide (Alumina)	Provides high resistance to wear and abrasion, good thermal insulation, and high resistance to oxidation (3600 F melting point). Can be applied by variety of methods (e.g., flame spraying, Flame-Plating and plasma jet) to almost every ferrous and nonferrous metal, as well as some plastics and other nonmetallic materials
Zirconium Oxide (Zirconia)	Because of higher melting point (4500 F) can be used at higher temp than alumina. However, is not as hard or as resistant to abrasion as alumina. Can be used on same materials as alumina
Cermet Coatings[c]	
Aluminum-Ceramic	Composed of a mixture of aluminum alloy powder and ceramic frits. Can be applied to carbon steels, low alloys and cast iron for oxidation protection to 1200 F. Has high resistance to thermal shock and impact
Chromium Carbide (flame sprayed)	High resistance to abrasion and oxidation up to 2900 F. Can be ground to smooth finish
Chromium Carbide (chromized)	Provides hard and wear resistant case on low carbon steels, many alloy and high chromium steels, and iron powder parts
Chromium-Nickel Boride	Protects iron and steel against attack by molten aluminum. Good resistance to thermal shock
Molybdenum Disilicide	Provides good oxidation resistance to 2900 F. Coating is brittle but this may not be important in nonstructural uses
Nitrided Surfaces	Essentially, nitriding provides a cermet coating. Process is limited to certain grades of steel and forms an extremely hard case which retains hardness up to 1100 F and is not subject to fatigue
Silicon Carbide	Improves erosion resistance of graphite up to 4000 F. Highly resistant to acids and alkalis
Tungsten-Carbon and Tungsten-Boron	High density (0.53 lb per cu in.) is useful in increasing weight in restricted places
Tungsten Carbide	Provides extreme hardness and wear resistance. Can be applied to almost all metals
Other Refractory Coatings[d]	
Aluminum Silicate (mullite)	Protective coating for graphite
Iron Titanate	Similar to titanium dioxide in properties, but coating is softer and hence less useful
Iron Titanate: Gamma Aluminum (50:50)	Coating is conductive and has melting point of 2500 F. Not widely used
Titanium Dioxide	Provides hardness and wear resistance. Coating is tough, has excellent adhesion and is not brittle
Zirconium Silicate	Provides high hardness and resistance to wear, corrosion and thermal shock. Coating is nonconductive and has good adhesion

[a] National Bureau of Standards.

[b] Many of these coatings are variations of NBS coatings. Coatings described are typical; many others are available for other base metals and special applications.

[c] In addition to the coatings described, recent announcement has been made of a number of other cermet coatings which can be applied by the plasma jet process. These coatings include refractory carbides of columbium, hafnium, tantalum, zirconium, titanium and vanadium. As of spring, 1959, these coatings are still largely in the experimental stage and little information is available on properties and applications. Molybdenum aluminide and nickel aluminide cermet coatings and rare earth (50% cerium oxide) refractory coatings can be applied by flame spraying but they do not appear to have any useful properties.

[d] In addition to the coatings described, a number of other refractory coatings can now be applied by the plasma jet process. These coatings are still experimental and property data is not yet available. The coatings encompass a wide variety of materials, including: 1) refractory oxides of thorium, hafnium, magnesium and cerium; 2) refractory metal compounds, such as borides of zirconium, tungsten, columbium, tantalum, titanium and chromium; 3) refractory metals, such as tungsten, tantalum, molybdenum and rhenium.

Mechanical Finishes for Aluminum, Copper and Stainless Steel [a]

Type ↓	Appearance	How Finish Is Obtained[b,c]	Uses
Smooth Bright (buffed)	Brightest mechanical finish. Surface is smooth and lustrous, can be made mirror-bright by using fine abrasive, electrobrightening in final polishing, or (on Al) chemical brightening. Cu must be plated or clear-lacquered to preserve appearance	Two or three buffing operations (with progressively softer buffs and/or finer compound) following polishing or other finishing operations. Skilled operator needed to prevent buff-burned or pitted surfaces. Approx buffing wheel speeds: stainless 10,000; Al 8000; Cu 6–10,000 sfpm. Al usually given light caustic etch between buffing steps to remove embedded particles	For attractive appearance or high reflectivity. Usually economically feasible only for larger items or close tolerance parts. Examples: household appliances, sanitary equipment, auto and boat trim, light reflectors, jewelry, small objects d'art. Also for Al before anodizing
Smooth Bright (burnished)	Not as bright as buffed surface esp if surface has retained oxide coating or has not been machined. Brightness depends on treatment time and relative movement and pressure of burnishing media	Gentle tumbling in barrel with stainless steel balls $\frac{1}{16}$–$\frac{1}{2}$ in. in dia and neutral soap solution (+ soap bark for Cu).[d] Time required: stainless, 1–4; Al, $1\frac{1}{2}$–$2\frac{1}{2}$; Cu, 6–48 hr. Hard to get uniform finish on complex-shaped parts	Similar to above, but generally smaller, mass-produced parts or parts difficult to buff. Examples: pen points, eyelets, grommets, auto trunk locks, auto push-buttons
Satin Semi-Bright (wheel or belt polished)	Smoothest sheen of the satin finishes because of finer, more irregular scratches. Brightness depends on fineness of abrasive in final operation. Tampico brush wheels produce slightly duller surface	Several polishing operations following grinding.[e] Wheels may be fabric, felt or leather. Lubrication usually required in wheel polishing with finer abrasives; belts reduce danger of overheating. Approx speeds: stainless 4500–7500, Al 5–6000, Cu 6–9000 sfpm. Abrasive usually alumina or silicon carbide (neither emery nor silicon carbide recommended for stainless). Preliminary polishing of Cu often done by sand-bobbing (using abrasive and wheel wet with mineral oil)	Parts where attractive, low reflection finish is desired. Examples: dairy, bar and cafeteria equipment; utensils; auto and furniture handles, knobs, rosettes. Also to prepare for finer finishes
Satin Semi-Bright (wire brushed)	Smooth sheen; smoothness dependent on wire size (thinnest wire for smoothest finish). Usually brighter than satin finish produced by polishing	Wire brushing of low polished surface entirely free of grease or oil. Brushes usually 10 in. in dia. Low pressures used. Wheel speeds from 2000 rpm for polished sheet to 600 rpm for castings (castings usually dustblasted or medium sandblasted before brushing). Nitric acid dip may be used after brushing to dissolve embedded particles	Same as above. Widely used on Al, sometimes on Cu. Not used on stainless because of its hard surface
Textured Semi-Bright (hammered)	Decorative finish somewhat similar to wrought silver. Minor scratches and defects obscured	Hammering by hand. Parts may be heated in smoky fire and hammered until soot is embedded; polishing of high spots then produces special decorative effect	Used on Al and Cu. Examples: architectural and commercial products, giftware, novelty items
Textured Semi-Bright or Matte (embossed or engraved)	Patterned finish having wide variety of decorative effects	Sheet passed between embossing rolls or pantograph-engraved; recesses may be filled with enamel for contrast and decoration. Applied to polished, buffed, satin finished, sandblasted (Al) or vapor honed (stainless) surfaces	Decoration and increase in rigidity. Limited to flat work. Examples: building panels, doors, nonskid surfaces, auto trim, plaques, tablets, nameplates
Textured Matte (sandblasted)	Special decorative effects, esp by combination with other processes. Surface texture depends on size and type of abrasive, amount of air pressure, and movement and angle of nozzle. Surface collects dirt unless protected, as by clear lacquer	Spraying surface with fine abrasive or slurry by air pressure. Careful control of nozzle is needed for desired effects and to prevent distortion. Contrasting surfaces obtained by enameling, anodizing, blackening, highspot polishing, caustic etching, etc.	Primarily for Al.[f] Examples similar to above; not limited to flat pieces

[a] Including aluminum and copper alloys.

[b] Stainless steel can be purchased with a number of different mill finishes. The bright cold rolled finish is usually specified for subsequent polishing or buffing. If severe forming is to be done, dull cold rolled may be preferable. Higher mill finishes available include polished, Tampico brush-finished and semi-mirror-finished.

[c] Aluminum mill finishes include a variety of embossed designs and a fluted finish.

[d] Another tumbling process—with granite chips, alumina or silica sand—is used to deburr and smooth stainless and aluminum parts, but does not produce as bright a surface and is not recommended for close tolerance parts.

[e] On aluminum, a somewhat brighter surface can be obtained by further finishing with steel wool and kerosene; a somewhat duller surface by low or coarse polishing followed by rubbing with steel wool and soapy water.

[f] Special effects on copper often achieved by engine turning. Stainless is usually vapor honed.

Porcelain Enamels

Composition

Porcelain enamels are inorganic glass coatings for metal that are formulated for specific applications. They are characterized by easy-to-clean, smooth, hard, lustrous surfaces that are resistant to attack by chemicals, heat and mechanical abrasion. They embrace a wide variety of compositions, all of which are similar in that they consist essentially of a glass matrix (usually alkali borosilicate) in which may be suspended crystalline opacifiers and pigments. When appreciable quantities of refractory compounds, such as alumina, chromic oxide or silica, are incorporated to increase heat resistance, these special porcelain enamels are termed ceramic coatings.

Conventional porcelain enamels for steel comprise one, two or three layers. The first layer is a dark colored 3 to 4-mil "ground coat" (analogous to an organic primer) containing an oxide of cobalt or nickel that promotes good adhesion to the steel. On other metals, where the oxide need not be present, the ground coat may be light colored or white. In addition to promoting adhesion, the ground coat also tends to cover or hide certain defects in the metal and on the metal surface. Where appearance is not important, the ground coat is frequently used as a single protective coating. Some of the single-coat porcelain enamels (the gray or speckled types) are attractive. They can also be made alkali resistant.

Ordinarily, one or two 3 to 5-mil layers of "cover coat" are applied to achieve a desired appearance or protection property. Two general types of cover coat are used: opaque white and non-opaque. Titanium dioxide, the opacifier used in most opaque white cover coats, is incorporated in the glass and crystallizes during the firing operation. It provides the high covering power that makes possible satisfactory coverage with a single 3 to 4-mil top coat. The oxides of tin, antimony and zirconium are also used as opacifiers, but to a lesser extent than titania.

Base Metals

Porcelain enamels can be applied to most metals and alloys provided the metal remains solid at the firing temperature and does not oxidize excessively during firing. Because fusion is accomplished at high temperatures and involves cooling over a fairly large temperature range, the coefficient of thermal expansion (or contraction) of the porcelain enamel should be slightly lower than that of the metal to which it is applied. This assures that the coating will be under compression at the operating temperature of the coated part. Compression is desirable because the coating, being a glass, has about ten times the strength in compression that it has in tension.

In addition to most ferrous alloys, porcelain enamels can be applied to gold, silver, platinum, copper, aluminum and superalloys. The more commonly used metals are:

Enameling iron. Low carbon, low metalloid, rimmed steel, specifically designed and specially processed for porcelain enameling. It is produced in sheets of various gages from about 30 to 11, and in two grades: regular and deep drawing. It has good resistance to sagging and distortion during firing of the porcelain enamel and produces a minimum of surface defects in the coating.

Cold rolled mild steel. Low carbon rimmed steel sheets (usually AISI 1008 or 1010) of good surface quality, available as commercial and deep drawing grades. This metal is subject to more warping during firing than enameling iron and is more likely to produce defects in the coating. For these reasons porcelain enamels applied to cold rolled mild steel are usually fired at temperatures below 1450 F.

Hot rolled steel plate. Hot rolled, low carbon steel plates of heavy gage are used primarily in the fabrication of domestic hot water tanks and other structures requiring strength and corrosion resistance. This metal is not suited for parts where appearance properties are of vital importance.

Special enameling steels. Special steels of low metalloid content specially processed to accept porcelain enamel cover coats without the use of a ground coat. One type has an extremely low carbon content (0.003% or less) and another is titanium-bearing.

Cast iron. Gray iron castings of the following composition: 2.50 silicon, 3.00 carbon, 0.70 phosphorus, 0.60 manganese, 0.08 sulfur and 0.40% combined carbon. Must have reasonably dense and uniform structure and must be free from porosity, slag inclusions and segregation.

Aluminum. Wrought and extruded alloys include: 1100, 3003, 6061, 6062, and 6063. Cast alloys include: 43, 356 and 344X. In selecting aluminum alloys for porcelain enameling, it should be remembered that maturing temperatures of the coatings are above the annealing temperatures of the "common" alloys.

Aluminized steel. Combines strength, rigidity and sag resistance of steel with many of the advantages of aluminum.

Stainless steel. Important base metal for ceramic coatings for parts operating at temperatures up to 1200-1800 F. The 300 and 400 series are most commonly used.

Appearance Properties

Color. Although certain colors are more difficult or expensive to control during application, the full spectrum of colors, including white and black, can be produced. Burgundies, purples and certain shades of orange and red are most difficult to control in production. Pigmenting materials are inorganic metallic compounds known as "ceramic oxides." Because they are chemically and thermally stable, they contribute to the color permanency associated with porcelain enamels.

Metallic lusters, such as copper, bronze, gold and platinum, can be produced, but are usually restricted to small patterns or designs.

Texture. Textural appearances available are best described by the method of producing them. These decorative processes include stippling or speckling, veiling, polytoning, graining and marbleizing, stenciling, printing, silk screening and decalcomania.

Opacity. The reflectance of white porcelain enamels ranges from 60 to 90%, as compared to 100% for magnesium oxide (ASTM Method C347 for Reflectance). Many tints of white extending into light pastels are also available.

Application Methods

Wet process. Simply stated, porcelain enameling is the process of re-fusing powdered glass into a continuous layer on the surface of a metal. In the wet process, water is used as a vehicle to facilitate application of the powdered glass. The mixture of solid

particles suspended in water, called a slip, can be applied by any of the methods used for organic coatings: spraying, dipping or flow coating. After the liquid slip is applied, water is removed by drying. The film of dry particles on the metal is then fused by heating for a short time at the temperature established for the particular coating composition involved.

Firing temperatures range from 1000 F, or below, for porcelain enamel on aluminum, up to 2000 F, or above, for some ceramic coatings applied to high temperature alloys. Porcelain enamels applied to sheet steel are fired at about 1350-1600 F. Most ground coats are fired at 1450-1550 F; most cover coats at 1400-1500 F. The ground coat is usually fired at a temperature 25-50 F higher than the temperature at which the cover coat is to be fired, although a number of specific ground-and-cover-coat combinations have been developed in which ground-coated and cover-coated pieces can be fired at the same temperature. Wet process cast iron and some new low-firing porcelain enamels for steel mature at temperatures as low as 1200 F. Some chemically resistant porcelain enamels (called glass coatings) are fired at temperatures as high as 1650 or 1700 F.

Dry process. Used primarily for heavy sections of cast iron or steel plate. The bare shape is heated to about 1700 F and then removed from the furnace. The porcelain enamel, in the form of a fine dry powder, is sprinkled on the hot surface. The coated piece is returned to the furnace to complete fusion of the porcelain enamel and to produce the very glossy, fire-polished surface that is characteristic of this process. A high degree of skill is required.

Chemical Properties

Acid resistance at room temperature. Porcelain enamels are tested for acid resistance at room temperature by the standard Porcelain Enamel Institute Test, PEI T-7 (ASTM C282). A porcelain enameled specimen is exposed to a 10% solution of citric acid for 15 min. The enamel is rated on the basis of the appearance of the treated area and the extent to which it retains soil. Ratings are: Class AA (no attack), A, B, C and D (complete loss of gloss).

Boiling acid resistance. Resistance to attack by boiling acid is evaluated in terms of weight loss per unit area produced by 2½-hr exposure to a boiling 6% solution of citric acid (ASTM C283).

Mineral acid resistance. Special porcelain enamels can be formulated to be resistant to attack by any mineral acid (except hydrofluoric) at any concentration and at temperatures up to the atmospheric boiling point of the acid.

Weather resistance. All porcelain enamels give excellent protection against corrosion if coverage is complete before installation, and if no severe mechanical damage occurs. For best resistance to loss of gloss and color change during prolonged weathering, only those porcelain enamels should be used that pass the acid resistance test described in the Porcelain Enamel Institute Specification for Archiectural Porcelain Enamels on Steel for Exterior Use (PEI S-100). Most such porcelain enamels have acid resistance of Class A or better.

Certain red and yellow acid-resisting porcelain enamels containing cadmium-selenium pigments may fade on prolonged exposure to weather. A copper sulfate spot test (described in PEI S-100) can be used to select red and yellow porcelain enamels that are free from such fading.

Alkali resistance. All porcelain enamels are highly resistant to attack by alkaline solutions at room temperature; all porcelain enamels are strongly attacked by boiling concentrated caustic solutions. Special porcelain enamels are available that have excellent resistance to attack by hot dilute alkaline solutions, such as detergents.

Thickness

Thickness of most porcelain enamel finishes will be in the following range:

Porcelain Enamel	Thickness Range, mils
One Coat on Steel	3-8
Normal Two Coats on Steel	7-11
Multicoat Finishes on Steel	11-25
Wet-Process Cast Iron	10-25
Dry-Process Cast Iron	25-70
Aluminum (1 or 2 coats)	2-10
Stainless Steel	2-10
Copper	2-20

Multicoat finishes are required for brilliant or saturated colors. Whites or pastel colors can be produced in one or two coats.

Physical and Mechanical Properties

Abrasion resistance. Porcelain enamels combine a Mohs hardness of 4 to 7 with an exceptionally smooth surface, resulting in good resistance to abrasion and mechanical wear. Abrasion resistance of a porcelain enamel is evaluated by a standard test, PEI T-2 (ASTM C448-59T).

Torsion resistance. Torsion resistance is evaluated by twisting a porcelain enameled metal angle until the coating fails by chipping along the apex (PEI T-5; ASTM C409). Values for a 12-in. long angle vary from about 30 deg for heavy coatings to over 180 deg for thin one-coat finishes.

Adherence. Degree of bonding between the porcelain enamel and the underlying metal is evaluated by subjecting a specimen to a controlled severe deformation that fractures the coating. Adherence is evaluated in terms of the percentage of the deformed area to which the coating adheres after the treatment (PEI T-17; ASTM C313).

Thermal shock resistance. Porcelain enamels are normally unaffected by very fast heating, but may be damaged by very rapid quenching from high temperatures. In general, thin coatings have greater thermal shock resistance than thick coatings. Very thick coatings may fail when immersed in ice water from a temperature of 300 F; thinner coatings may be undamaged when quenched from 800 F. Ceramic coatings have been quenched repeatedly from 1600 F without damage.

Heat resistance. Most porcelain enamels are viscous at their firing temperatures. The upper temperature limit for prolonged exposure is about 400 °F below the firing temperature, although this temperature can be exceeded for brief periods without damage. The upper temperature limit for prolonged service will vary from about 600 F for porcelain enamels on aluminum to 1100 F for some porcelain enamels on steel. Ceramic coatings have been developed for temperatures above 2000 F.

Chemical Conversion Coatings

Purpose and Type	How the Coatings Compare	Metals That Can Be Coated[a]									
		Aluminum	Cadmium	Copper	Iron	Magnesium	Silver	Steel	Tin	Titanium	Zinc
To Improve Paint Bonding											
Phosphate	Rough crystalline structure provides excellent paint adhesion. Better paint bond than chromate coatings. Corrosion confined to limited area when paint film damaged	X	X		X	0		X	0		X
Chromate	Provides high corrosion protection because of nonporous structure. Paint adhesion generally not as good as with phosphate	X	X	0		X	0				X
To Improve Corrosion Resistance											
Anodic	Provides equal or better corrosion protection—at higher cost—than chromate	X				X					0
Chromate	Generally provides much better corrosion resistance than phosphate. Nonporous structure acts as moisture barrier. If coating is broken, inhibiting action of soluble chromate retards corrosion of basis metal	X	X	X		X	0				X
Phosphate	Not generally used alone for corrosion protection. When treated with oils, waxes or stains, however, it provides good protection, especially on ferrous surfaces	X	0		X			X	0		X
Oxide and Other	Do not provide as much protection as other conversion coatings, but cost is lower	0	0	0	0			0			0
For Decoration											
Chromate	Available in wide variety of natural and dyed colors. Colors are not as light-fast as in colored anodic coatings	X	X	X		X					X
Anodic	Can be colored with a large variety of dyes and pigments. Underlying metal can be used to impart attractive metallic sheen. Sealing required	X				X					0
Phosphate	Little decorative value except when painted	X	X		X	0		X	0		X
Oxide and Other	Black and blue-black coatings widely used to decorate ferrous, zinc and cadmium surfaces. Considerable number of colors producible on copper and aluminum	X	X	X	X			X			X
To Aid in Cold Forming											
Phosphate	By preventing metal-to-metal contact, lubricated coating facilitates deep drawing, cold heading, extrusion, and wire and tube drawing	X			X			X			X[b]
Oxide and Other	Special coatings have been developed for titanium									X	
To Improve Wear Resistance											
Phosphate	Maintains continuous oil film between bearing surfaces; prevents welding of surfaces under load				X			X			
Anodic	Hard anodic coating with greater thickness and weight than conventional anodic coatings increases wear and abrasion resistance	X				X					

[a] X—Metals most commonly treated for purpose listed. O—Metals less commonly treated. [b] Electroplates.

Rust Preventives[a]

Type ➜	Oil Type	Solvent Type	Emulsifiable Type	Wax Type (applied hot)
Metals Coated	Generally applied to ferrous metals; nonferrous metals sometimes with extreme care			
Coating Composition, Structure	Non-setting mineral oils of various weights and viscosities; thin oily layer, thickness depending on viscosity	Petroleum-base film-forming materials and rust inhibitors dissolved in petroleum solvents; soft to hard, depending on composition	Petroleum-base rust preventives modified to form stable emulsions when mixed with water	Waxy layer; soft to firm, depending on composition
Application Methods	Brushing, spraying, dipping, flushing	Brushing, spraying, dipping, flushing	Brushing, spraying, dipping, flushing	Heating and then dipping, brushing or swabbing; special techniques required (for spraying)
Appearance	Transparent oily film	Transparent to black	Transparent oily to tacky film	Transparent, brown, amber, or black
Thickness, mil	0.2–0.3	0.2–0.4; occasionally up to 2.0	0.2	1.5–3.0
Pretreatment	Alkaline, solvent or emulsion cleaning; scaly surfaces should be freed of all deposits by mechanical cleaning. Emulsifiable coatings can often be applied directly			
How Coatings Removed	Removal seldom required; solvent rinsing, vapor degreasing, emulsion spraying, or alkaline washing	Removal often unnecessary; solvent rinsing or alkali cleaning	Removal seldom required; solvent rinsing	Solvent rinsing or alkali cleaning
Properties				
Durability	Excellent protection for indoor storage	Excellent indoor protection from 4 months to 2 years; in some cases, can also be used outdoors	Excellent indoor protection for 1-2 years	Good protection indoors (up to 3 years) and outdoors (1-2 years)
Adhesion	Good[b]	Good[b]	Good[b]	Good[b]
Abrasion Resistance	Fair	Fair	Fair	Good
Impact Resistance	Very good	Very good	Very good	Very good
Heat Resistance	Up to 120–140 F			
Typical Uses	Internal combustion engines, gear cases, hydraulic systems, highly finished auto parts, galvanized products, steel sheet, bar, wire	External surfaces of machinery and tools; highly finished surfaces; steel sheet, bar and wire		Any highly finished part stored for prolonged periods of time, e.g., ball bearings
Cost, ¢/sq ft[c]	0.026	0.09–0.1	0.04–0.06[d]	0.14–0.67

[a] Rust preventives are essentially petroleum-type coatings designed to provide low cost corrosion protection during manufacture, shipment and storage.
[b] Soft types can be wiped off, but hard types have relatively good adhesion. Degree of adhesion is also influenced by porosity of base metal.
[c] Approximate costs for materials alone, exclusive of equipment and handling costs.
[d] For a 7:1 ratio of water to emulsion.

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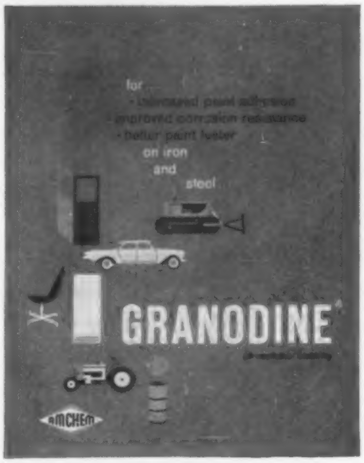

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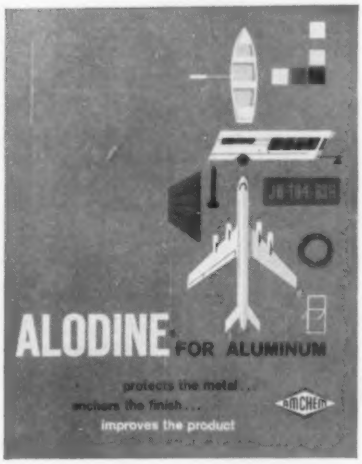

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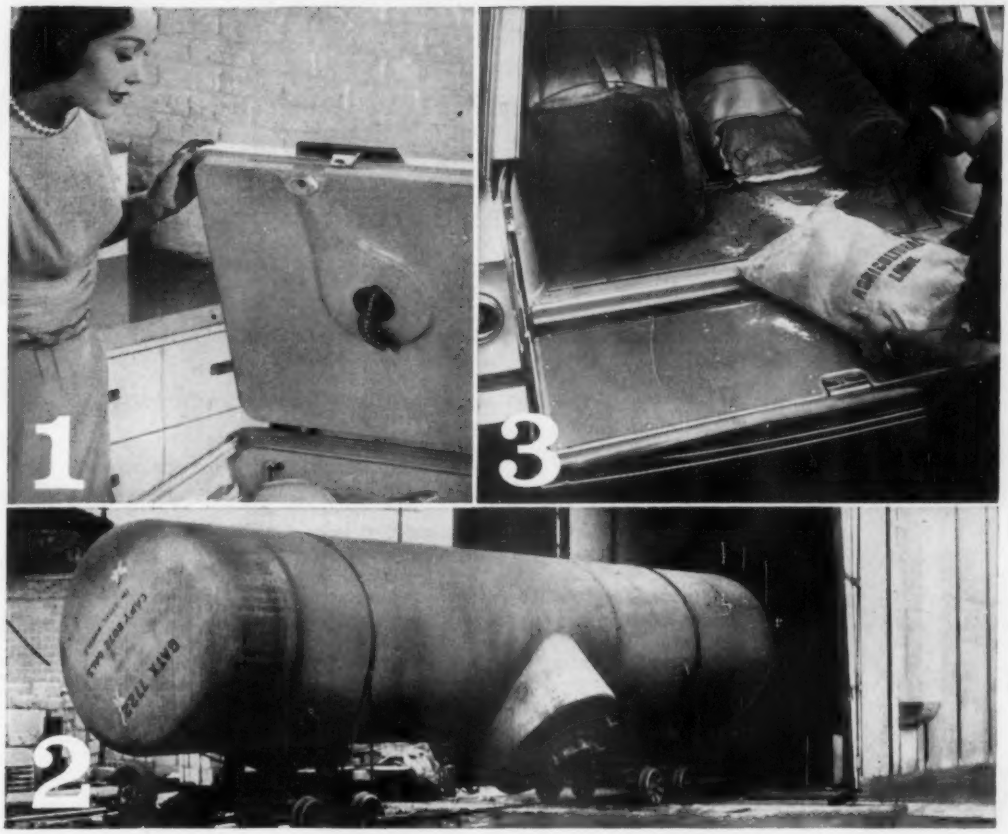

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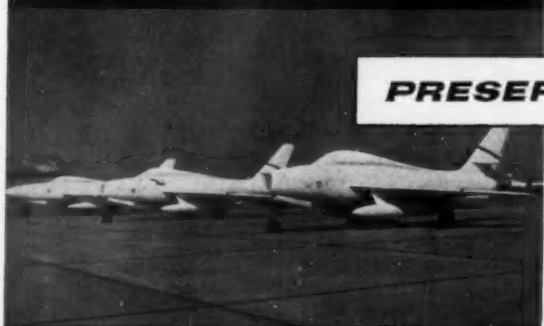

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COMPOSITE MATERIALS

Plastics-Metal Laminates

Although there are many possible combinations, vinyl-metal laminates probably account for about 90-95% of all plastics-metal laminates now used. A relatively new laminate, polyester-steel, is discussed briefly below.

The wide range of uses for vinyl-metal laminates includes electrical products, transportation equipment, luggage and carrying cases, household products and building applications. Their main advantages are: high decorative appeal, strength and light weight, resistance to wear and abrasion, resistance to most chemicals, and ease of fabrication.

Materials. In general, any ferrous or nonferrous base metal can be used. However, the three most common metals in use today are cold rolled steel, aluminum and magnesium. A steel base is selected where strength and low cost are dominant design factors. Aluminum is used where lightness and/or corrosion resistance is required. Magnesium is usually used only when extreme lightness is required (e.g., luggage and carrying cases).

Any of these base metals can be laminated with vinyl on one or both sides. Ordinarily, a single-side laminate is sufficient for product interiors. However, a double-side laminate may be required if the reverse side of the laminate must have special properties.

The reverse side of a laminate may also be provided with a wide variety of organic finishes or electroplates. For added decorative appeal and resistance to rust and corrosion, reverse sides can be easily plated with zinc, chromium, copper, cadmium or nickel without damaging or discoloring the vinyl layer.

Properties.

Appearance—Probably the most noteworthy characteristic of vinyl-metal laminates is their outstanding appearance. The number of textures and colors that can be produced is almost unlimited. Typical of the textures now being produced are leathers, textiles, wood grains, high gloss matte finishes, nonreflecting matte finishes, and marbleized finishes. All of these textures can be produced in practically any color.

Chemical resistance—The high-molecular-weight polyvinyl chloride resins used in vinyl laminates are inherently chemically stable. However, some types of vinyl films are given a clear protective coating of up to 2 mils for added resistance to corrosion, staining, abrasion and handling. In addition, vinyl laminates are also resistant to 48-hr exposure to such common media as petroleum, alkalis, citric acid, Clorox, ammonia, milk, animal oil, vegetable oil and greases.

Abrasion, wear and heat resistance—Vinyl-metal laminates have outstanding abrasion and wear resistance. In general, maximum recommended operating temperature is about 200 F. The laminates show no loss of adhesion and no tendency to delaminate after 600-hr exposure to 150 F. Laminates exposed to 210-250 F will not show any surface damage unless pressure is applied to the surface while it is hot.

Thickness. A vinyl film of 10 to 15 mils has proved satisfactory for most applications. However, films as thin as 4 mils and as thick as 25 mils, and higher, are available. Thickness of the base metal depends on the structural requirements of the application. The practical laminating thicknesses for steel are 0.012 in. to 0.06 in., for aluminum 0.016 in. to 0.125 in., and for magnesium 0.016 in. to 0.081 in. Sheets are available in sizes up to 52 × 120 in. and larger. Also, coil stock in 40-in. widths is available in almost any length.

Forming, joining. Vinyl-metal laminates are easily drawn and formed on existing equipment. The maximum draw that can be obtained is generally limited by the forming properties of the base metal. However, any draw that can be made in one operation is satisfactory; the metal cannot be annealed. Any die lubricant can be used; however, water-soluble or silicone-base lubricants are recommended.

Vinyl-metal laminates can be also crimped, bent and spun. Normal cutting and shearing operations are permissible provided the vinyl side of the laminate is exposed to the cutting edge. When shearing a double vinyl laminate, the side with the thinner vinyl film should be away from the cutting edge.

Vinyl-metal laminates can be readily fastened with conventional sheet metal screws, bolts, rivets, lock nuts, and speed nuts through drilled or pierced holes. Brazing and soldering do not produce very strong joints and are used only in a few isolated applications.

A resistance welding technique has recently been developed which makes it possible to produce a high strength weld on the back of a steel laminate without indenting or burning the vinyl or affecting its bond. Welding is accomplished by using two copper alloy electrodes that contact the workpiece on the same side.

Polyester-metal laminates. This relatively new plastics-metal laminate, consisting of polyester resin on strip steel, offers the following characteristics: good moisture, abrasion, weather and stain resistance; and the ability to be deep drawn, lock seamed, roll formed, sheared, crimped, bent and pierced. They can be joined only by mechanical means at present. However, new heat joining methods and adhesives are being investigated.

The laminate is available in any color and most textures, and is produced in widths up to 48 in. in continuous rolls.

Metal-Wood Laminates

Although many combinations of metal facings and wood cores are possible, the most commonly used materials are steel and aluminum faces and plywood cores.

Metal-wood laminates are used for a wide range of applications, including truck and trailer side panels; railway car interiors, bulkheads and doors; kitchen cabinets; instrument boxes and cabinets; bus and truck doors; locomotive sheathing; foundry patterns; outdoor signs; and architectural applications of all kinds.

Properties. The primary advantage of metal-wood laminates is excellent rigidity at low weight and cost. A typical ⅜-in. thick laminate, made of plywood sandwiched between faces of zinc-coated steel, has a stiffness factor equal to that of 1/16-in. thick solid oak, ⅜-in. thick aluminum plate, or ¼-in. thick steel plate. For the same conditions, 1 sq ft of the metal-wood laminate weighs 3.3 lb, as compared to 2.8 lb for oak (which has nearly twice the thickness), 5.4 lb for aluminum plate, and 10 lb for steel plate.

Other characteristics include: versatility (the laminates are available in a wide range of sizes, thicknesses, edges, cores and faces to meet specific end service requirements); uniformity; fire resistance; smooth surfaces; sound dampening; and ease of fabrication.

Materials. Virtually any combination of metal and wood can be produced. The three most widely used combinations are: 0.029-in. thick zinc-coated steel bonded to plywood on one or both sides; 0.020-in. thick aluminum alloy 3003 bonded to plywood on one or both sides; and 0.025-in. thick type 18-8 stainless bonded to plywood on one side only or with zinc-coated steel on the other.

Other laminates sometimes used involve faces of monel, lead, porcelain enameled steel, and a combination of aluminum and steel; and cores of wood veneer, wallboard, hardboard, balsa wood and insulation board.

Sizes, thicknesses. Standard widths, lengths and thicknesses of wood-metal laminates are as follows: for laminates consisting of zinc-coated steel on one or both sides or aluminum on one or both sides, available widths range from 30 to 48 in.; available lengths range from 72 to 144 in.; and thicknesses range from ¼ to 1 in.

For laminates consisting of stainless steel on one side alone or with zinc-coated steel on the other side, widths are 30, 36, or 48 in.; lengths are 96 or 120 in.; and thicknesses range from ¼ to 1 in. Greater thicknesses can be obtained if desired.

Tolerances on length and width are the same as those for the metals used. Thickness tolerances (including the metal faces) are held to ±0.015 in.

Forming, joining. Metal-wood laminates can be easily worked with standard tools. Generally, selection of the cutting tools should be determined by the metal facing. The laminates can be sawed, drilled, bored, notched and routed.

Although metal-wood laminates are usually used as flat sheets, panels with metal facing on one side only can be curved to a certain degree. For example, a ¼-in. panel with steel on one side can be bent to a 9-in. radius.

Metal-wood laminates can be joined by soldering (except those with aluminum faces), adhesive bonding and mechanical fastening, including sheet metal screws, bolts, machine screws, sleeve nuts, etc. For hinges, locks, hangers, handles and other hardware fittings, tapping plates should be used to eliminate through fasteners and add strength.

STIFFNESS AND WEIGHT OF PLYWOOD-METAL LAMINATES[a]

Plywood Thickness, in.	No of Plies	EA, 1000 lb/in. width[b]		EI, 1000 sq in.-lb/in. width[c]		Bending Moment (max), in.-lb/in. width		Weight, lb/sq ft
		Long.	Trans	Long.	Trans	Long.	Trans	
STEEL (0.024-in.) BOTH SIDES								
¼	3	1671	1628	28.9	27.3	388	366	2.79
⅜	3	1755	1755	63.8	58.8	604	556	3.13
⅜	5	1786	1724	62.7	59.9	596	566	3.13
½	5	1936	1784	112.5	104.8	822	765	3.53
⅝	5	2060	1870	175.1	163.8	1040	974	3.83
¾	5	2070	2070	249.7	239.6	1250	1200	4.23
¾	7	2070	2070	254.2	235.2	1270	1180	4.23
1	7	2185	2375	450.0	440.0	1720	1680	5.00
1⅛	7	2385	2385	594.1	579.2	2030	1975	5.35
ALUMINUM (0.016-in.) BOTH SIDES								
¼	3	551.6	508.8	7.7	6.0	131	103	1.25
⅜	3	635.0	635.0	18.4	13.4	217	158	1.58
⅜	5	666.6	603.2	17.4	14.5	205	171	1.58
½	5	816.0	664.0	34.2	26.6	308	240	1.98
⅝	5	940.0	750.0	56.1	44.7	410	327	2.28
¾	5	950.0	950.0	81.3	71.1	499	437	2.68
¾	7	950.0	950.0	85.7	66.6	527	409	2.68
1	7	1065.0	1255.0	158.4	148.2	738	690	3.46
1⅛	7	1265.0	1265.0	211.1	196.2	875	813	3.81

[a] Longitudinal and transverse refer to direction of plywood face grain with respect to span length.
[b] EA is modulus of elasticity times cross-sectional area. Must be considered in composite materials.
[c] EI values computed on following basis: E for fir plywood is 1.6×10^6 psi for long plies and 80×10^3 psi for transverse plies; ultimate fiber stress in bending for fir is 8000 psi; for steel, E is 30×10^6 psi and ultimate fiber stress in bending is 60,000 psi; for aluminum, E is 10×10^6 psi and ultimate fiber stress is 24,000 psi.

Honeycomb Sandwich Structures

A wide variety of core and facing materials are possible with honeycomb sandwich structures, each composition offering a special combination of properties to meet specific end service requirements. In general, all honeycomb sandwich structures offer these characteristics: high strength-to-weight ratio; resistance to heat transfer and vibration; use of nearly any structural material; close tolerances; high speed production; and ease of fabrication.

Honeycomb sandwich structures are used in practically every aircraft or missile flying today. Typical of aircraft uses are wings, ailerons, rotor blades, trailing and leading edges, doors, flooring, bulkheads, stabilizers, radomes, fuselage sections, elevators and rudders. They are also used for such commercial applications as building wall panels, flooring for trailers, small boat hulls, shipboard doors and bulkheads, table tops, pallets, truck panels and doors, stressed skin buildings, furniture, etc. Some recent applications include gas turbine seals, oil seals, heat radiators, shock absorbers, electromagnetic shielding and noise suppressors.

Honeycomb sandwich theory. Honeycomb structures can be best compared to I-beams. The facings correspond to the flanges, the object being to place a high density, high strength material as far from the neutral axis as possible and thus increase the section modulus. The honeycomb core is comparable to the web of an I-beam which supports the flanges and allows them to act as a unit. The honeycomb, like the web, carries the shear stresses. However, honeycomb differs from I-beam webs in that it maintains continuous support for the facings, allowing the facings to be worked up to or above their yield strength without crimping or buckling. The adhesive which bonds the honeycomb to its facings must be capable of transmitting shear loads between the two components, thus making the entire structure an integral unit.

When the sandwich panel is loaded as a beam, the honeycomb and the bond resist shear loads while the facings resist the moments due to bending forces, and hence carry the tensile or compressive load. When loaded as a column, the facings alone resist the column forces while the core stabilizes the facings to prevent buckling.

Although comparable to I-beams, honeycomb sandwich structures are actually more efficient. The combination of high density facings and low density cores provides a much higher section modulus per unit density than any other known construction method. Thus, for an equivalent rigidity factor, weight of an aluminum-faced honeycomb sandwich structure beam is only 1/6 that of birch plywood, 1/10 that of solid aluminum and 1/16 that of solid steel.

Facing materials. Theoretically, any thin, bondable material with high tensile or compressive strength-weight ratio is a potential facing material for honeycomb panels. The materials most commonly used for facings are aluminum, steel, glass-reinforced plastics and wood. The facing can be finished with special exterior effects, such as decorative paints and enamels, or rough surfaces for anti-skid floor panels. In some cases, the skin may be embossed with a regular pattern to provide a special effect.

Aluminum—Alloys such as 7075-T6, 2024-T3 and 2014-T6 are commonly used facing materials in thicknesses from 0.010 in. to 0.064 in. for structural, as well as nonstructural, applications. Aluminum is generally not used for applications where temperatures exceed 400 F for long periods of time. Anodizing or coating with a protective resin can be done where increased corrosion resistance is desired.

Stainless steel, superalloys—Because of their good strength at elevated temperatures, these facings are finding increased usage in aircraft. Some of these facings have been found to perform satisfactorily at tempertaures as high as 2000 F. Porcelain enameled steel is also available for special applications.

Glass-reinforced plastics—Where parts must have a complex contour, glass-reinforced plastics are ideal. They also offer these special advantages: excellent weight control—it is easy to build up material where it is needed and leave faces thin where excess material is not needed; excellent insulation and heat reflections; excellent medium temperature strength; high strength-weight ratio; high impact strength; and compatibility with other materials.

Plywood—Plywood facings are available for both structural and nonstructural applications. The most common use of plywood facings, however, is in interior and exterior doors of buildings. Plywood facings for doors are usually bonded to a paper honeycomb core.

Resin-impregnated paper—Paper facing materials are generally used for flat, nonstructural panels such as interior walls and partitions.

Core materials. Honeycomb cores are produced from a number of materials, including aluminum, glass or asbestos-reinforced plastics, and paper. In addition, stainless steel, titanium, and some superalloy cores have been developed for special environmental applications. Theoretically, any metal that can be made into a foil and then welded, brazed or adhesive bonded can be made into a honeycomb.

Aluminum—Cores are supplied in the expanded or unexpanded form in thicknesses from 0.060 in. to 18 in. or more. By varying cell size and gage, honeycomb density can be closely controlled over a wide range. Aluminum core is available in cell sizes varying over a range of densities from 1.2 to 8.1 lb per cu ft.

The two most common aluminum alloys used are 3003-H19 and 5052-H39. The major difference between the two alloys is that the 5052 alloy has about 20% more compressive and shear strength at equal densities. Alloy 5056 is now available in a few cell sizes and densities.

Stainless steels, superalloys—These alloys are generally used where service temperatures are too high to permit use of aluminum or glass-reinforced plastics (this is also true of titanium). Alloys most

commonly used for temperatures above 900 F are these heat treatable stainless alloys: 17-7PH, PH 15-7Mo, AM-350 and AM-355; and these heat treatable superalloys: A-286, Inconel X and L 605.

Non-heat treatable metals, such as the plain austenitic stainless steels (AISI 321) and Inconel, are used for light loaded parts at temperatures up to about 1800 F. Above 1800 F, only the refractory metals, such as molybdenum, tantalum or columbium, can be used.

Titanium—Although titanium honeycombs are more or less competitive with stainless steel, their use is limited by difficulties encountered in forming and machining. Alloys most commonly used, however, are Ti-75, 6 Al-4 V, A110 and the DOD alloys.

Glass-reinforced plastics—Many formulations are available, most of which are made by impregnating a glass cloth with resin, expanding to a honeycomb structure, curing, and repeatedly coating with a polyester, phenolic, epoxy or silicone resin. These cores are generally available in cell sizes ranging between 3/16 in. and ⅜ in., and in thicknesses ranging from 0.060 in. to 18 in. Density, which ranges from 2.5 to 16 lb per cu ft, can be varied by changing cloth thickness and amount of coating. Glass-plastics cores are normally formed in regular blocks or slices but are available in slices pre-curved to specified contours.

Paper—Paper honeycomb is usually impregnated with a phenolic resin for strength, rigidity and moisture resistance. Cell sizes vary between ⅛ in. and 1.2 in. Standard core thicknesses are available from ¼ in. to 6 in. Depending on paper thickness and amount of impregnation, densities range between 1.5 and 4.0 lb per cu ft.

Design. The loads, their orientations and the configuration of the part determine the type of stresses which must be resisted. Generally, these stresses fall into the following categories: compression, tension, shear, peel and buckling. Honeycomb sandwich structures are almost always designed for flexural loading and therefore consist of thin, high density facings bonded to a relatively thick, low density honeycomb core.

The same formulas used to calculate stresses in I-beams can be used to determine the stresses developed in honeycomb panels. Other important design criteria include the following:

Creep—Creep properties of a honeycomb panel under load are primarily a function of the adhesive, the service temperature and the time at temperature. With proper selection of the adhesive, most creep requirements can be easily met.

Impact—In some cases, high concentrated impact loads, especially in flooring applications, outweigh all other design considerations. A thin facing material will generally satisfy all tensile and compressive requirements, but thicker facings are usually specified to resist impact. A thicker facing distributes the impact load over a wider area, thus reducing the stress on the core.

Often floor panels are designed with different facing thicknesses to provide maximum resistance at areas of greatest impact. When panels are subjected to extremely high impact loads, a thin wood veneer or layer of phenolic laminate is bonded to the facing.

Fatigue—Honeycomb sandwich structures are probably more resistant to fatigue than any other construction due to the continuous nature of the bonded surface. The most critical parts of the structure in regard to fatigue are the attachment points. When subjected to fatigue tests, a panel will usually fail at these points.

Environment—Temperature, time at temperature, moisture, and the existence of various fluids and gases are all important design considerations. However, all of these factors are dependent upon the materials being used. Suggested sandwich structures for elevated temperatures are given in the table at the bottom of this column.

Joining. Honeycomb sandwich structures can be joined by several methods.

Generally, honeycomb structures cannot withstand the compressive loads caused by bolts, rivets, screws, and other mechanical fasteners. However, a great number of inserts and special fasteners have been devised to overcome this problem. Inserts include wood, plastics or metal strips; molded-in plastics blocks; and aluminum spacer inserts.

Stainless steel and other heat resistant honeycombs can be joined by resistance welding and brazing.

The most common method used is adhesive bonding. Several types of adhesive are used: rubber-base cements, a combination of thermosetting resins and elastomeric polymers, epoxy resins, epoxy-phenolic systems, and duplex tapes consisting of a supported film adhesive (combination thermosetting resin and elastomeric polymer) on one side and a film of semi-liquid epoxy on the other.

RECOMMENDED HIGH TEMPERATURE STRUCTURES

Temp, F	Core	Facing	Remarks
Up to 350	Aluminum	Aluminum	Retains ¾ strength at 300 F; 2/3 at 350 F
Up to 500	Glass-reinforced plastics	Steel or titanium	Retains good strength at 500 F; some resins begin to deteriorate after few hours
350-1000	Steel	Steel or titanium	Depends on brazing materials, alloy used and temper; silver brazing alloys good to 850 F

Combination Plastics Laminates

Plastics laminates combined with other materials can provide special combinations of properties that are not obtainable with any single material.

These combination laminates consist of various plastics laminates bonded to such other materials as copper, aluminum, rubber, etc. Specific characteristics offered by combination laminates include: 1) high strength-weight ratio; 2) excellent resistance to corrosion and chemicals; 3) great range of electrical characteristics; 4) dimensional stability over a wide temperature range; 5) high rigidity and strength for soft sealing materials; 6) good bearing surfaces; 7) great range of frictional characteristics; and 8) good fabrication characteristics and low production costs.

Materials, forms. Theoretically, any material can be combined with plastics laminates by adhesive bonding. However, because of similarities in design requirements for various types of end uses, several combinations have become somewhat standardized.

The most common plastics laminates used are the paper-base phenolics, such as NEMA grades XXXP, XX, XXP and XP. Other grades used quite frequently are C, CE, L and LE fabric-base phenolics; G-3 glass-melamine; G-5 glass-phenolic; and G-10 glass-epoxy.

The materials most commonly supplied in combination with plastics laminates are copper, natural and synthetic rubbers, cork, asbestos, steels, aluminum alloys, vulcanized fibre, and polyester and cellulose acetate films. Two grades of plastics laminates may also be combined.

Combination laminates are available in sheet, rod or tube form. In sheet form, the plastics laminate can be specified on one or both sides, or sandwiched between laminae of other materials. When a tubular form is used, the combination material consists of a plastics laminate covering a metal tubular core.

Properties, uses.

Copper-faced laminates—Probably the most widely used combination laminates are the copper-faced laminates used for printed circuits. Laminates are available with electrolytic or rolled copper foil in thicknesses of 0.00135 in. (1 oz), 0.0027 in. (2 oz) or greater, bonded to either one or both sides of an XXXP base. This grade is generally used because it has excellent insulation resistance, good punching qualities, and low dielectric losses even under high humidity conditions.

Bond strength for most copper-faced laminates is between 4 and 8 lb per in. width for 1-oz foil and slightly higher for 2-oz foil. Copper-faced laminates made by a new process have about twice the bond strength, but lower surface resistivity.

Vulcanized fibre-clad laminates—These combination laminates provide high arc resistance and a wide range of toughness, impact strength, rigidity and appearance, depending on the grade and thickness of the laminate and the fibre. They are used for such things as switchgear in both low and high voltage applications.

Asbestos-clad laminates—Asbestos paper bonded to plastics laminates provides a combination with high heat and arc resistance and is used for arc barriers and reflectors in high voltage arc interrupting devices.

Aluminum-clad laminates — These combination laminates are used extensively for engraving stock. They are also used as plate holders for x-ray machines where aluminum acts as the shield. Used as a piston head in aircraft shock struts, it provides the following advantages: it eliminates metal-to-metal contact, it is lightweight, mechanically strong, shock resistant, impervious to hydraulic oils, and stable over a wide temperature range. Aluminum-clad laminates also offer possibilities as a printed circuit material, but soldering remains a problem.

Beryllium copper-clad laminates—This composite material offers possibilities for printed circuits because of beryllium copper's good conductivity and nonmagnetic characteristics.

Silver and gold-faced laminates—The extremely high electrical conductivity of silver and gold makes these combination laminates particularly promising as electrical contact materials. The plastics laminate provides strength and insulation properties.

Bimetallic Castings

Bimetallic castings are actually composite materials in which aluminum and magnesium alloys are molecularly bonded to steel, stainless steel and other ferrous metals.

In the process, the light metal is cast against a specially processed surface of the ferrous metal using any of the standard casting methods—sand, permanent mold, plaster mold, or pressure die casting. Typical uses for these composite materials are brake drums, engine cylinders, clutch rotors, guided missile control fins, impellers, pistons, gears, hydraulic manifolds and valve housings.

Main advantage of bimetallic castings is the ability to combine the strength, hardness, fatigue resistance, etc. of ferrous metals with the lightweight, high heat conductivity and other characteristics of light metals.

Metals used. Light metals used are pure aluminum and magnesium and any of their common casting alloys. Aluminum alloys include 43, 132, 142, 195, 220, 356, Almag 35, and Frontier 40-E; magnesium alloys include AZ92A, AZ63A and AZ91C.

Ferrous metals include gray, malleable, ductile and austenitic cast irons; and carbon, alloy and stainless steels. Aluminum and magnesium alloys can also be bonded to Inconel, the Nimonics, nickel, titanium and some other alloys.

Properties. In the case of iron and aluminum, the bond, which is essentially an intermetallic compound of the two, has a tensile strength of 15,000 psi and can withstand shearing stresses of the order of 7000 psi. The bond retains its properties at temperatures above 500 F and is both vibration-proof and leakproof. Galvanic attack is impossible because there are no voids at the interface.

Design. The major factor to be considered in designing bimetallic castings is the difference in expansion coefficients between the light metals and the various ferrous metals. Despite the difference, separation is generally prevented by the strength of the intermetallic bond.

Special attention must also be given to the selection of light metal casting alloys. It is generally not possible to solution treat (T-6) because of the thermal shock placed on the bond during quenching. Alloys specified should, therefore, either be usable in the as-cast condition or be responsive to artificial aging.

Preplated and Precoated Metals

Surface and Coating Method ↓	Base Metal		Critical Functions, Properties	Typical Applications
	Metal	Form		
Aluminum (hot dipped)	Low carbon steel or copper-bearing	Sheet, strip	High heat reflectivity. High temperature oxidation resistance. Forms refractory alloy at 1000 F. Strong, low cost base	Oven door liners, aircraft firewalls, auto mufflers, broiler and toaster parts, baffles for space heaters, jet engine parts
	Steel (ASTM A122)	Strand (7-wire)	Galvanic protection. Strong base. Longer life than zinc-coated steel	Guy wires, span wires, overhead ground wires
Brass, Copper (plated)	Low carbon steel	Sheet, strip	Decoration. Atmosphere resistance. Good solderability	Luggage, hardware, costume jewelry. tubing, frames, stands
	Zinc	Sheet, strip	Decoration	Molding, ornaments, trim, badges, buttons
Bronze[a]	Low carbon steel	Strip	Decoration. Atmosphere resistance. Strong base. Conserves copper	Ornamental trim, shell cases
Chromium[b] (plated)	Aluminum, brass, copper, zinc	Sheet, strip	Decoration	Toys, reflectors, trim, signs, auto accessories
	Low carbon steel	Sheet, strip	Decoration, atmosphere resistance	Heater and toaster shells, tubes
Lead[c] (plated)	Low carbon steel	Sheet, strip	Atmosphere resistance. Good solderability, drawability	Telephone cable sheathing, containers
(plated or hot dipped)	Copper (ASTM B101)	Sheet, strip	Atmosphere resistance	Roofing, flashing
(hot dipped)	Low carbon steel	Sheet, strip	Atmosphere resistance. Good solderability, drawability. Paint base	Ammunition boxes, ducts
Terne[d] (hot dipped)	Low carbon steel	Sheet	Atmosphere resistance. Good solderability, drawability. Paint base	Gasoline tanks, caskets, paint and oil containers, door frames
Nickel[e] (plated)	Low carbon steel	Sheet, strip	Decoration, atmosphere resistance	Toys, nameplates, trays, knives
Tin (plated)	Low carbon steel	Sheet, strip	Resistance to atmosphere, chemicals. Good solderability. Strong, low cost base	Food product cans, kitchenware, bearings (babbitting base), parts to be soldered
(hot dipped)	Low carbon steel	Sheet, strip	Same as above	Tin cans for food products
Zinc (plated)	Low carbon steel	Sheet, strip, flat wire	Atmosphere resistance. Galvanic protection. Strong, low cost base	Lighting fixtures, refrigerator parts, spools and reels, oil cans, signs
(hot dipped)	Low carbon steel (incl ASTM A123)	Plate, bar, sheet, strip, shapes	Same as above	Agricultural, refrigerator and air conditioning parts, auto mufflers
	Carbon or low alloy steel (ASTM A53)	Tubing, pipe, conduit	Same as above	Water pipe. Electrical and hot air conduits
	Low carbon steel	Wire	Same as above	Fencing
Alkyd Baking Enamel	Low carbon steel, aluminum	Strip	Decoration, atmosphere resistance	Venetian blinds, auto dashboards, lighting fixtures, awnings
Polyvinyl Chloride	Steel, aluminum, magnesium	Sheet, strip	Decoration. Resistance to atmosphere, chemicals. Abrasion resistance. Formability. Low cost base	Business machine housings, auto panels, television cabinets, air conditioner housings
Vinyl Lacquer or Enamel	Low carbon steel, aluminum, brass, zinc	Strip	Decoration. Atmosphere resistance. Formability	Caps, lipstick cases, garden tools, toys, eyelets, flashlight parts
Other	Steel, aluminum, brass, zinc	Strip	Same as above	Toys, reflectors, brackets, frames, caps, movie reels, ash trays, auto moldings and trim, novelties

[a] 90–10. [b] Over nickel. [c] Sometimes over copper. [d] 75–85% lead. [e] Over copper.

Clad Metals

Surface ↓	Base Metal		Critical Functions, Properties	Typical Applications
	Metal	Form		
Aluminum and Its Alloys				
Aluminum [a]	Low carbon steel	Strip	High temperature oxidation resistance. At 1000 F forms alloy with 85% emissivity. Cheaper than carbonated nickel or nickel-clad steel. Conserves nickel	Anode plates for electronic receiving tubes
Aluminum [b]	Low carbon steel	Strip	Same as above, but suitable for higher temperatures	Anode plates for receiving tubes where close spacing makes temperatures too high for aluminum
1100	Aluminum (2024)	Sheet	Atmosphere resistance. Galvanic protection. Strong base	Aircraft frames, cooking utensils, hardware
6053	Aluminum (2014)	Sheet	Atmosphere and wear resistance. Galvanic protection. Workable base	Power shovel bails, aircraft fittings, heavy duty forgings
6053	Aluminum (5056)	Wire	Same as above	Insect screening
7072	Aluminum (3003 or 3004)	Sheet	Atmosphere resistance. Galvanic protection. Workable, weldable base	Cooking utensils, gasoline and oil tanks, bus and train trim
7072	Aluminum (3003)	Tube	Same as above	Heat exchangers
7072	Aluminum (7075)	Sheet	Atmosphere resistance. Galvanic protection. Strong base	Aircraft structural parts
Copper and Its Alloys				
Brass [c]	Low carbon steel	Strip	Decoration. Atmosphere resistance. Good solderability	Cosmetic cases, frames, gaskets
Brass [d]	Low carbon steel	Wire	Decoration. Atmosphere resistance. Strong base. Conserves brass	Curtain rods, indoor television antennas, lamp stands
Copper	Carbon steel	Wire, ribbon	Electrical conductivity. Atmosphere resistance. Strong base. Conserves copper	Lead-in wires for electronic tubes, communication and power lines, springs
	Aluminum (1100 or 5052)	Sheet, strip, tubing, wire, bars	Thermal, electrical conductivity. Good solderability. Lightweight base. Conserves copper	Waveguides, variable condenser blades, heat transfer fins, jewelry, shims, bushings
	Beryllium copper (25)	Strip	Electrical conductivity. Good spring properties	Current-carrying springs
	Low carbon steel	Strip	Atmosphere resistance. Thermal conductivity. Good solderability. Strong base. Conserves copper	Gaskets, automotive radiator tanks, electrical contacts and switches, immersion heater base plates
	High carbon steel	Strip	Electrical conductivity. Plating base. Good spring properties	Clips, thin-blade or spiral-type springs
	Low alloy steel (with boron)	Wire	Electrical conductivity. Atmosphere resistance. Strong base. Conserves copper	Grid support rods for electronic tubes, communication lines, plated costume jewelry
	Carbon or low alloy steel	Plate, heads	Resistance to corrosion, erosion. Conserves copper	Chemical process equipment
Cupro-Nickel	Low carbon steel	Strip	Same as above	Chemical process equipment
Phosphor Bronze [c]	Copper	Strip	Good spring properties. Base has high electrical conductivity	Current-carrying springs and blades
Gold and Its Alloys				
Gold [e]	Bronze, nickel-silver, nickel, sterling silver	Strip, tubing wire	Decoration. Atmosphere resistance. Relatively low cost base	Jewelry, including watchcases, bracelets, rings, lockets
Gold [f]	Copper, brass, nickel, monel	Strip	Chemical resistance. Relatively low cost base	Bursting disks, other chemical process equipment
Lead and Its Alloys				
Lead [g]	Copper, low carbon steel	Tubing	Chemical resistance. Good strength, high thermal conductivity	Heat exchanger coils for chemical process equipment
Lead	Low carbon steel	Plate, sheet, strip, rod	Chemical resistance. High density. Strong base	X-ray, radium, nuclear and chemical equipment

[a] ½% silicon. [b] ½% silicon with 330 nickel on other side. [c] 70–30 or 85–15. [d] Over copper. [e] 10 K or more. [f] 14 K or more. [g] ASTM B29.

Clad Metals

Surface ↓	Base Metal		Critical Functions, Properties	Typical Applications
	Metal	Form		
Nickel and Its Alloys				
Inconel, Monel	Carbon or low alloy steel	Plate, heads	Resistance to corrosion, erosion. Low cost base. Conserves nickel	Process equipment
Nickel	Copper	Wire, ribbon	High temperature oxidation resistance. Electrical conductivity	Electrical circuits subjected to high temperatures
Nickel	Iron or carbon steel	Wire, ribbon	Atmosphere resistance. High temperature oxidation resistance	Grid support rods, lead-in wire for tubes; typewriter key levers, springs
A Nickel	Copper	Wire, ribbon	Corrosion resistance. Electrical conductivity	Electrical circuits subjected to corrosive atmospheres
A or L Nickel	Carbon or low alloy steel	Plate, heads	Resistance to corrosion, erosion. Low cost base. Conserves nickel	Process equipment
L Nickel	Brass, low carbon steel	Strip	Same as above.	Process equipment
330 Nickel	Low carbon steel	Strip	High temperature oxidation resistance. High emissivity. Conserves nickel	Anode plates for electronic receiving tubes
Platinum and Platinum Group Alloys, Silver				
All	Copper, brass, bronze, nickel	Strip	Electrical contact properties. Chemical resistance. Low cost base	Electrical contacts, slip rings, chemical crucibles
Platinum	Copper, brass, bronze, nickel	Tubing, wire	High chemical resistance. Low cost base. Thermal conductivity	Heat exchangers for chemical processes
Platinum	Molybdenum	Wire	High work function (low primary electron emission). Refractory base	Grids for tubes, particularly for use with thoriated cathodes
Silver	Copper, nickel	Wire, ribbon	Atmosphere resistance. High temperature oxidation resistance. Electrical conductivity. Low cost base	High temperature coils, high frequency conductors, braiding for radar cables
	Aluminum (1100, 5052)	Strip	Electrical contact properties. Electrical conductivity. Lightweight, low cost base. Decoration	Conductors, contacts in aircraft electrical equipment. Costume jewelry
	Aluminum, brass	Tubing	Electronic transmission characteristics. Low cost base	Waveguides for electronic transmission lines
	Beryllium copper (25)	Strip	Electrical conductivity and contact properties. Good spring and fatigue properties	Contact arms for buzzer circuits, other current-carrying springs
	Copper, brass	Strip	Electrical contact properties. Low cost base	Electrical contacts, slip rings, flexible waveguides
	Invar	Strip	Good electrical contact properties. Low thermal expansion	Television antenna connectors
	Monel, nickel	Strip	Electrical contact properties. Corrosion resistance. Low cost base	Electrical contacts subject to corrosion or excessive wear
	Phosphor bronze (A,C,D)	Strip	Electrical conductivity and contact properties. Good spring properties	Electrical contact springs
Stainless Steel				
Austenitic [a]	Copper	Strip	Resistance to corrosion, erosion. Thermal conductivity. Workable base	Heat exchangers for chemical processes
Ferritic [b]	Copper	Strip	Corrosion resistance. Thermal conductivity. Uniform heat transfer. Workable base. Decoration	Pots and pans
Stainless	Carbon or low alloy steel	Plate, heads	Resistance to corrosion, erosion. Workable, low cost base metal	Process equipment
Stainless	Low carbon steel	Sheet, plate	Same as above. Decoration	Process equipment, auto bumpers, grilles and trim, display cases, sterilizers
Ferritic	Low carbon steel	Strip	Corrosion resistance. Decoration. Workable, low cost base metal	Cooking utensils, auto bumpers, grilles and trim

[a] 304, 310. [b] 430.

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FORMS AND SHAPES

FORMS AND SHAPES

Metal Forms—Process, Advantages, Limitations

Form ↓	The Process	Advantages	Limitations
Sand Castings	GREEN SAND—Moist, bonded sand is packed around a wood or metal pattern, the pattern removed, and molten metal poured into the cavity; when metal solidifies, mold is broken and casting removed	Almost any metal can be used; almost no limit on size and shape of part; extreme complexity possible; low tool cost; most direct route from pattern to mold	Some machining always necessary; large castings have rough surface finish; close tolerances difficult to achieve; long, thin projections not practical; some alloys develop defects
	DRY SAND—Same as above except: core boxes used instead of patterns, sand bonded with a setting binder, and core baked in an oven	Same as above plus ability to handle long, thin projections	Usually limited to smaller parts than possible with green sand
Shell Mold Castings	Sand coated with a thermosetting plastic resin is dropped onto a heated metal pattern (which cures resin); shell halves are stripped off and assembled. When poured metal solidifies, shell is broken away from finished casting	Rapid production rate; high dimensional accuracy; smooth surfaces; uniform grain structure; minimized finishing operations	Some metals cannot be cast; requires expensive patterns, equipment, and resin binder; size of part limited
Permanent Mold Castings	Mold cavities are machined into metal die blocks designed for repetitive use; molten metal is gravity-fed to cavity (pressure sometimes applied after pouring). Mold consists of two or more parts and is hinged and clamped for easy removal of castings	Good surface finish and grain structure; high dimensional accuracy; repeated use of molds (up to 25,000); rapid production rate; low scrap loss; low porosity	High initial mold costs; shape, size and intricacy limited; high melting metals such as steel unsuitable
Die Castings	Molten metal is poured into closed steel die under pressures varying from 1500 to 25,000 psi; when the metal solidifies, the die is opened and the casting ejected	Extremely smooth surfaces; excellent dimensional accuracy; rapid production rate	High initial die costs; limited to nonferrous metals; size of part limited
Plaster Mold Castings	Slurry of special gypsum plaster, water and other ingredients is poured over pattern and allowed to set; pattern is removed and the mold baked. When poured metal cools, mold is broken for removal of casting	High dimesnional accuracy; smooth surfaces; almost unlimited intricacy; low porosity	Limited to nonferrous metals; limited to relatively small parts; mold-making time is relatively long
Investment Castings	Refractory slurry is cast around (or dipped on) a pattern formed from wax, plastic or frozen mercury; when slurry hardens, pattern is melted out and mold is baked. When poured metal solidifies, mold is broken away from casting	High dimensional accuracy; excellent surface finish; almost unlimited intricacy; almost any metal can be used	Size of part limited; requires expensive patterns and molds; high labor costs
Centrifugal Castings	Sand, metal or graphite mold is rotated in a horizontal or vertical plane (true centrifugal method); molten metal introduced into the revolving mold is thrown to mold wall where it is held by centrifugal force until solidified	Good dimensional accuracy; rapid production rate; good soundness and cleanliness of castings; ability to produce extremely large cylindrical parts	Shape of part limited; spinning equipment expensive
Open Die Forgings	Compressive forces (produced by hand tools or mechanical hammers) are applied locally to heated metal stock; little or no lateral confinement is involved. Desired shape is achieved by turning and manipulating work-piece between blows	Simple, inexpensive tools; useful for small quantities; wide range of sizes available; good strength characteristics	Limited to simple shapes; difficult to hold close tolerances; machining to final shape necessary; slow production rate; relatively poor utilization of material; high degree of skill required

Metal Forms—Process, Advantages, Limitations

Form	The Process	Advantages	Limitations
Closed Die Forgings	Compressive forces (produced by a mechanical hammer in a mechanical or hydraulic press) are applied over the entire surface of heated metal stock, forcing metal into a die cavity of desired shape. There are several types of closed die forgings	Relatively good utilization of material; generally better properties than open die forgings; good dimensional accuracy; rapid production rate; good reproducibility	High tool cost for small quantities; machining often necessary
	BLOCKER TYPE—Uses single impression dies and produces parts with somewhat generalized contours	Low tool costs; high production rates	Machining to final shape necessary; thick webs and large fillets necessary
	CONVENTIONAL TYPE—Uses preblocked workpiece and multiple impression dies	Requires much less machining than blocker type; rapid production rates; good utilization of material	Somewhat higher tool cost than blocker type
	PRECISION TYPE—Uses minimum draft (often 0 deg)	Close tolerances; machining often unnecessary; excellent material utilization; very thin webs and flanges possible	Requires intricate tooling and elaborate provision for removing forging from tools
Upset Forgings	Heated metal stock is gripped by dies (which also form the impression) and pressed into desired shape	Fair amount of intricacy possible; good dimensional accuracy; rapid production rate	Limited to cylindrical shapes; finish not as good as with other forgings; size of part limited; high die costs
Cold Headed Parts	Similar to upset forging except metal is cold. Wire up to about 1 in. dia is fed to die in punch press and positioned with one end protruding; this end mushrooms out under force of punch and is formed between die and punch face	Good surface strength; alloys used are generally tough, ductile and crack resistant; excellent surface finish; no scrap loss; rapid production rate	Head volume and shape limited; internal stresses may be left at critical points; size of part limited
Impact (cold) Extruded Parts	BACKWARD EXTRUSION—A metal blank is placed in the cavity of a die and struck with a punch moving at high velocity; the metal is forced upward through the opening between punch and die and rises along punch. FORWARD EXTRUSION—A thick blank, usually preformed, is struck by a punch and flows forward through an opening in the die to a considerable distance beyond end of punch	Rapid production rate; good dimensional accuracy; good-surface finish; few secondary operations required; low scrap loss; good strength characteristics; low tool cost	Choice of materials restricted; shape of part limited to tubular; length-to-diameter ratio limited; size of part limited
Stampings, Drawn Parts	CUTTING—Blanking, punching, piercing, shearing, parting, notching, lancing, slitting, etc.; metal is completely sheared by stressing beyond the ultimate strength. FORMING—Bending, stretch forming, coining, embossing, etc. Metal is stressed beyond yield point and permanently deformed. DRAWING—A special forming operation in which a flat blank or sheet is pressed into a dished shape	Almost any metal can be used; rapid production rate; excellent surface finish; good uniformity; no porosity; generally low materials cost; wide variety of shapes and sizes possible	High tool costs; often high materials waste; limited to relatively thin sections; sheared edges are rough
Spinnings	A rotating flat or preformed metal disk is drawn over a male form by the application of pressure from a simple, round-ended wood or metal tool, or from a small roller; the male form is either wood (for small quantities) or steel (for large quantities)	Low cost; good surface finish; parts get into production quickly; good strength and hardness due to cold working	Relatively slow rate of production; generally limited to round, symmetrical shapes; skilled labor necessary; close tolerances difficult to achieve; thickness of blank limited

continued on next page

Metal Forms—Process, Advantages, Limitations

Form ↓	The Process	Advantages	Limitations
Screw Machine Parts	Bar stock is fed automatically through a hollow spindle into a collet where it revolves and is cut by various tools carried in turret and on tool slides. Four major types of machines: hand, single spindle automatics, multiple spindle automatics, and Swiss-type automatics (for long slender work). Operations performed include: turning, forming, facing, drilling, tapping, threading, burnishing, boring, cutting off, lettering, swaging, cross drilling, reaming, knurling, milling, recessing (broaching), cross milling	Extremely high production rate; excellent dimensional accuracy; excellent surface finish; wide choice of materials; low tool cost; excellent uniformity; low lead time requirements	Depending on design, considerable turnings may be generated; cross section of part is limited to a circle, hexagon, square or other readily extruded shape; size of part limited
Powder Metallurgy Parts	Powdered metals are placed in a die and compressed into finished form; the formed part is then heated (sintered) in an atmosphere-controlled furnace to about two-thirds the melting point of its principal constituent. Finished parts can be infiltrated with a lower melting metal, oil impregnated, heat treated, coined, machined, case hardened, etc.	Control of density and porosity, with resulting control of properties; rapid production rate; no scrap loss; smooth surfaces; close tolerances (by coining); use of materials that cannot be alloyed by conventional means; elimination of costly secondary operations	Shape and size of parts somewhat limited; part must be ejectible from a die; high tooling cost; not practical for short runs
Electroformed Parts	A mandrel, which is a negative or mirror image of part to be made, is placed in an electroplating bath until the desired thickness of metal deposit is obtained; the matrix is removed from bath and separated from built-up part which is self-supporting	Extremely high dimensional accuracy; excellent surface finish; excellent control over properties; practically no size limitations; considerable intricacy possible	Relatively slow production rate; scratches and tiny cracks reproduced; highly skilled technician required; metal cannot be deposited in recesses that are deeper than they are wide; selection of materials limited
Cut Extrusions	Metal is heated to plastic state and forced through a die having an aperture of desired shape; material emerges from die in the form of a continuous ribbon which is cut to proper length	Allows metal to be placed where needed; can produce great variety of relatively complex shapes; no porosity; low tool and die cost	Size of dia limited; openings must be in the direction of extrusion action; limited to parts of uniform cross section (along length); close tolerances difficult to achieve
Sectioned Tubing	Tubing can be made by extruding, piercing or drawing of rod or welding of sheet, strip or plate. It can then be formed in a number of ways, including bending, swaging, spinning, upsetting, flaring, expanding, beading and grooving, machining and joining, etc.	Good surface finish; excellent strength; good dimensional accuracy; practically all metals can be used	Limited to tubular shapes
Roll Formed Parts	Metal sheet, strip or coiled stock is fed at room temperature through successive pairs of rolls and continuously formed into shapes having cross sections similar to those produced by extrusion	Extremely rapid production rate; good dimensional accuracy; good surface finish; great variety of complex shapes; almost any metal can be used	Not economical for runs under about 25,000 ft; high tooling cost; limited to shapes with uniform cross section (along length)
Continuous Castings	Molten metal (usually bronze) is continuously gravity-fed into a mold, rapidly cooled and withdrawn, and then cut into sections of desired length	Low cost; rapid production rate; can handle metals that cannot be extruded; no porosity or casting defects; uniform density and grain structure; good mechanical properties	Limited to parts of uniform cross section (along length); holes must be in direction of casting; limited to bronze alloys; maximum and minimum size of cross section limited

Metal Forms—Choice of Materials[a]

Form ↓	Irons	Steels (Carbon, Low Alloy)	Heat & Corr Res Alloys	Aluminum Alloys	Copper Alloys	Lead Alloys	Magnesium Alloys	Nickel Alloys	Precious Metals	Refractory Metals	Tin Alloys	Titanium Alloys	Zinc Alloys
Sand Castings	■	■	■	■	■	▣	■	■			▣		▣
Shell Mold Castings	■	▣	▣	■	■			▣					
Permanent Mold Castings	■	▣		■	▣	▣	■	▣			▣		▣
Die Castings				■	▣	■	■				▣		■
Plaster Mold Castings				■	■								
Investment Castings		■	▣	■	■			▣					
Centrifugal Castings	■	■	■	▣	▣			▣					
Open Die Forgings	▣	■	■	▣	▣		▣	▣		▣		▣	
Closed Die Forgings Blocker Type		■	■	▣	▣		▣	▣		▣		▣	
Conventional Type		■	■	▣	▣		▣	▣		▣		▣	
Precision Type				▣	▣		▣						
Upset Forgings		■	■	▣	▣		▣	▣		▣		▣	
Cold Headed Parts		■	▣	■	■	▣		▣					
Impact (cold) Extruded Parts		▣		■	▣	▣	▣				▣	▣	▣
Stampings, Drawn Parts		■	▣	▣	■		▣	▣	▣	▣		▣	▣
Spinnings		■	▣	■	■	▣	▣	■	▣			▣	▣
Screw Machine Parts	▣	■	▣	■	■		▣	■	▣				▣
Powder Metallurgy Parts[b]	■	■	▣		■			▣		▣		▣	
Electroformed Parts[c]	■			▣	■	▣		■	■		▣		▣
Cut Extrusions		▣		■	■	▣	■	▣			▣	▣	
Sectioned Tubing		■		■	■		■	■					
Roll Formed Parts		■		▣	▣		▣					▣	▣
Continuous Castings					■[d]								

[a] ■ = Materials most frequently used.
▣ = Other materials currently being used.

[b] Iron-copper and iron-copper-carbon most frequently used.
[c] Most frequently used material is iron (99.8% pure).
[d] Particularly tin bronze and tin-lead bronze.

Metal Forms—Complexity of Part

Form ↓	Overall Size		Section Thickness, in.		Bosses	Undercuts	Inserts	Holes[a]
	Max	Min	Max	Min				
Sand Castings	Green—20–30 tons; dry—5000–6000 lb	1 oz	No limit in floor and pit molds	Al—3/16; Cu—3/32; Fe—1/8; Mg—5/32; steel—1/4–1/2	Yes—small added cost	Yes—small added cost	Yes—small added cost	3/16–1/4 in.
Shell Mold Castings	Sev hundred lb; usually <25 lb	1 oz	[b]	1/16–1/8	Yes	Yes	Yes	1/8–1/4 in.
Permanent Mold Castings	25 lb	Sev oz	2.0	Iron—3/16; Cu, Al—3/32–1/8; Mg—5/32	Yes—small added cost	Yes—large added cost, reduced production rate	Yes—no difficulty	3/16–1/4 in.
Die Castings	35 lb; usually <10 lb	Sev oz	5/16 preferable; usually <0.50	Cu, Mg—0.031–0.062; Al—0.040–0.080; Zn—0.015–0.050	Yes—small added cost	Yes—large added cost, reduced production rate	Yes—considerably reduced production rate	Cu—3/16; Al, Mg—3/32; Zn—1/32
Plaster Mold Castings	100 lb; usually <15 lb	1 oz	—	0.040–0.060	Yes—moderate added cost	Yes—no difficulty	—	1/2 in.
Investment Castings	Sev hundred lb; usually <10 lb	1 oz	0.50	0.025–0.050	Yes—some difficulty	Yes—considerably higher cost	—	0.020–0.050 in.
Centrifugal Castings	Ferrous—50-in. dia, up to 50-ft length; nonferrous—72-in. dia, up to 27-ft length	Ferrous—1 1/8-in. dia; nonferrous—1-in. dia	4.0[c]	0.250[c]	Possible	No	Yes	Yes
Cold Headed Parts	10 by 3/4-in. dia	1/16 by 1/32-in. dia	—	—	Yes—either under or on top of head	Yes	No	No
Impact (cold) Extruded Parts	Al: 6-in. dia by 80 in. Steel: 4 5/8-in. dia by 80 in. Mg: 6 1/2-in. dia by 52 in. Pb, Sn: 3-in. dia Zn: 2 1/2-in. dia by 8 in.	1/4-in. dia 1/2-in. dia 3/8-in. dia 3/8-in. dia 1/2-in. dia	0.010–0.5[d] 0.875 0.250 0.015 0.14	0.0035–0.062 0.035 0.006 0.003 0.010	Yes—no difficulty on bottom, but should be symmetrical	No—only with secondary operations	Yes—but slows down production rate	Yes—forward extrusion; normally not on backward extrusion
Spinnings	15-ft dia	1/4-in. dia	1.0; 4–5 in. possible on special machines[e]	0.004: usually 0.024	No—annular ribs and beads possible	Yes—no difficulty	No—requires subsequent operations	No—unless contained in blank

[a] For castings, figures shown are minimum cored hole dia. [b] Avoid section differences where max-min ratio is more than 5:1.
[c] Wall thickness. [d] Some authorities state that maximum wall thickness is not known. [e] Thicker materials can be used when hot working.

Metal Forms—Complexity of Part

Form ↓	Overall Size		Section Thickness, in.		Bosses	Undercuts	Inserts	Holes
	Max	Min	Max	Min				
Stampings, Drawn Parts	CUTTING—18-20 in.	⅛ in.	1.0; usually <0.650	0.003–0.005	Yes—width: depth should be 4:1	No	No	Yes—dia not be less than metal thickness
	FORMING	—	1.0	0.003–0.005	Yes—width: depth should be 4:1	Yes	No	Yes—no difficulty if hole is not near bend
	DRAWING—20-ft dia by 3-ft depth	⅛-in. dia	1.0	0.003–0.005	Yes—width: depth should be 4:1	Yes	No	No—unless contained in blank
Screw Machine Parts	SINGLE—8-in. dia by 3 ft	1/32-in. dia by 1/16 in.	—	—	Yes—with special tooling arrangements and added costs	Yes	No	Yes—depths up to 5 times dia possible in one setup; depths to 10 times dia possible with special tooling arrangement
	MULTIPLE—8⅛-in. dia by 20 in.	1/16-in. dia by ¼ in.	—	—		Yes	No	
	SWISS—½-in. dia by 6 in.	0.005-in. dia by 1/32 in.	—	—		Yes	No	
Powder Metallurgy Parts	50-sq in. cross section; 6-in. height. Max length-dia ratio is 2½:1; sometimes as high as 7:1	⅛-sq in. cross section; 1/32-in. height	—	0.032 per ¾ in. of length[c]	Yes—slope of edge must be at least 2 deg min	No—only by secondary machining	Yes—but difficult; should be avoided	Yes—in the direction of pressing; length-dia ratio should be held to 4:1; holes <3/16 in. increase tooling cost
Electroformed Parts	Limited only by size of tanks—up to 50 lb or more	No real limit—as little as a few oz	0.5 in.; in some cases up to 2 in.	<0.0001 in.	Yes—keep as shallow as possible	Yes—with nonpermanent mandrels	No	Yes
Cut Extrusions	Dia—part contained within 21-in. circle; length—up to 40 ft	—	Sev in.	0.040	Yes—no difficulty	Yes—no difficulty	No	Yes—only in direction of extrusion
Sectioned Tubing	20–25-in. dia	⅛-¼-in. dia	6.0[a]	0.02[a]	Yes	Yes	Yes	Yes
Roll Formed Parts	80-in. width; normally <20 in.	<1-in. width	0.750; usually <0.125	<0.005	Yes	Yes	No	Yes—if uniformly spaced
Continuous Castings	9 in.	½ in.	—	⅛	Yes—no difficulty	Yes—no difficulty	No	Yes—only in directions of casting; ⅛ in. min

Metal Forms—Dimensional Characteristics[a]

Form ↓	Dimensional Tolerances	Draft Allowance	Machine Finish Allowance, in.	Surface Smoothness, μ in. rms
Sand Castings	Gray iron—3/64 in./ft; malleable iron —1/32 in./ft; steel—1/16 in./ft; Al, Mg—1/32 in./ft; Cu—3/32 in./ft	1-2 deg	IRON STEEL NONFER <6 in.... 3/32 ..... 1/8 ..... 1/16 6-12 in.... 1/8 ..... 3/16 ..... 1/16 12-20 in.... 5/32 ..... 1/4 ..... 3/32 20-60 in.... 3/16 ..... 1/4 ..... 1/8-1/4	100-1000
Shell Mold Castings	0.005 in./in.; as little as 0.003 in. total possible	1/4-1/2 deg	Often none required	50-250
Permanent Mold Castings	0.015 in./in. for first inch; add 0.001-0.002 for each added inch. May be cut to 0.010 in. total	2 deg min on each side; usual range is 2-3 deg. In recesses, 5 deg desirable. Standard allowances: 0.015-0.020 in./in.	1/32 for parts up to 4 in.; 1/16 for parts greater than 4 in.	100-250
Die Castings	Cu—0.003-0.005 in./in.; Al, Mg—0.0015-0.002 in./in.; Zn—0.001-0.0025 in./in.	2 deg min on each side; usual allowances (in.) are: Al, Mg, Pb, Sn—0.010-0.015; Zn—0.005-0.007; brass, bronze—0.015-0.020	1/32-1/64	40-100
Plaster Mold Castings	0.005 in./in. for first inch; add 0.001 for each additional inch. Common total: 0.005-0.010 in.	1/2-1 deg	1/32	30-50
Investment Castings	Ferrous—0.004 in./in.; nonferrous—0.002 in./in. Avg: 0.005 in./in. on >1 inch	Often no draft required; 1/2-1 deg for single-parting, noncored dies	0.010-0.025	10-85
Centrifugal Castings	PIPE O.D., in. TOL, in. 3-12 .... 0.06 14-24 .... 0.08 30-36 .... 0.10 42-48 .... 0.12 I.d. tol about 50% greater	1/8 in./ft	Ferrous—3/32-1/8 for small castings, 1/4 for larger castings; nonferrous—1/16 for small castings, 1/4 for larger castings	100-500

Form	Thickness Tolerances, in.	Shrinkage and Die Wear Tol	Draft Angle Tol, deg	Fillet and Corner Tol	Mismatching Tol, in.	Machine Finish Allowance, in.
Closed Die Forgings[b]	0.2 lb .... −0.008, +0.024 1.0 lb .... −0.012, +0.036 5.0 lb .... −0.019, +0.057 10.0 lb .... −0.022, +0.066 50.0 lb .... −0.038, +0.114	SHRINKAGE: 0.003 in./in. DIE WEAR: 0.003 in. per 2-lb net wt of forging	DROP, PRESS: 7 on outside, 10 on inside; UPSET: 3 on outside, 5 on inside	0.3 lb ..... 3/32 1.0 lb ..... 1/8 3.0 lb ..... 5/32 10 lb ..... 3/16 30 lb ..... 7/32 100 lb 1/4	Up to 1 lb; 0.015 (commercial), 0.010 (close); add 0.002-0.003 for each 6 lb	<3 lb ...... 1/32 <40 lb ...... 1/16 100 lb ...... 3/32 200 lb ...... 1/8 Allow 1/8 in. on all upset forgings

Form	Shank and Shoulder Dia Tolerance, in.	Shank Length Tolerance, in.[c]	Head Dia Tol, in.	Head Ht Tol, in.
Cold Headed Parts	1/16-3/16 in., 0.002; 3/8 in., 0.003; 3/4 in., 0.0045; 1 in., 0.005	Up to 1 in., 1/32; 1-2 in., 1/16; 2-6 in., 3/32; >6 in., 3/16	1/32	0.005

Form	Length Tol, in.	Wall Thickness Tol, in.	Bottom Thk Tol, in.	Outside Dia Tol, in.	Inside Dia Tol, in.	Draft Allowance	Surface Smoothness
Impact (Cold) Extruded Parts	0.010 to 3/16; usual: 0.015	0.004-in. thick .... 0.0002 0.014-in. thick .... 0.002-0.003 0.060-in. thick .... 0.002-0.0045 0.100-in. thick .... 0.010 >0.150-in. thick ... 0.020	0.003-0.007	0.003-0.005	0.000-0.006	None	10-70 μ in. rms

[a] Tolerances are for usual commercial practice, stated for guide only. In most cases, closer tolerances can be held at increased cost. Tolerances are overall unless otherwise indicated. All values are ± unless otherwise stated.

[b] For drop hammer forgings, thickness tolerances apply to overall thickness measured perpendicular to parting plane of the dies. For upset forgings, thickness tolerances apply to metal actually enclosed and formed by dies, measured parallel to direction of travel of the ram. Fillet and corner tolerances apply to all intersection surfaces. Tolerances for open die forgings are considerably greater since there is little or no lateral confinement of stock

[c] For dia up to 3/4 in. For larger dia, tolerances are: up to 1-in. length, 1/16; from 1-2 in. 1/8; over 2 in. 3/16.

Metal Forms—Dimensional Characteristics

Stampings, Drawn Parts

CUTTING	Dim. Tol, in.	Flat. Tol, in.	Squareness Tol, in.	Punched Hole Tol, in.	Surface
	0.003–0.010	0.005	0.003–0.010	0.005–0.010	Good to exc

FORMING	Min. Bend Radii	Angle Tol, in.	Surface
	Depends on metal, condition and thickness; normally not less than 1/16–1/32 in., or metal thickness, whichever is greater	0.010	Good to exc

DRAWING	Dimensional Tol, in.[d]	Max Reduction in Drawing[e]	Surface	Draft Allowance
	Sheet thickness 1/32–1/4 in.: 0.005–0.015 (up to 2-in. dia); 0.008–0.020 (up to 6-in. dia)	40–50%	Good to exc	0.0005–0.0025 in./in.

Spinnings

Length Tol, in.	Inside Dia Tol, in.	Wall Thickness Tol, in.	Min Corner Radii	Surface Smoothness
0.005	Up to 6 in.: 0.002; >6 in.: 0.003	0.002	4t	6–8 μ in. rms

Screw Machine Parts

Dia Tol, in.	Length Tol, in.	Concentricity, TIR	Corner Radii, in.	Hole Tol, in.	Surface Smoothness, μ in. rms
0.001–0.003; 0.0005 at slower speeds	0.005; 0.002 if length is less than 2 in.	0.003	Any radius or chamfer	0.0005–0.005	63–125; instrument parts average 5–16

Powder Metallurgy Parts

Diameter Tol, in.	Length Tol, in.	Corner Radii	Concentricity, TIR[f]	Draft Angles	Surface Smoothness, μ in. rms
1.5 in. . . . . . +0.001, −000 2.5 in. . . . . +0.0015, −000 3.0 in. . . . . . +0.002, −000 4.0 in. . . . . . +0.003, −000 5.0 in. . . . . . +0.004, −000 6.0 in. . . . . . +0.005, −000	Small parts: +0.010, −000; larger parts: +0.020, −000	0.005 times 45-deg chamfer; never less than 1/64 times 45 deg	1.5-in. dia . . . . . 0.003 4.0-in. dia . . . . . 0.005 5.0-in. dia . . . . . 0.006 6.0-in. dia 0.007	None usually required, except for bosses and flanged parts; 2 deg sufficient	30–120; 12–15 (sized parts)

Electroformed Parts

Dimensional Tol, in. (permanent mandrel)	Dimensional Tol, in. (fusible mandrel)	Wall Thickness Tol, in.	Surface Smoothness, μ in. rms
0.0002	0.002	0.001	2–8

Cut Extrusions

Length Tol, in.	Flatness Tol, in.	Straightness Tol, in.	Cross Section Tol, in.	Curved Surface Tol, in.	Wall Thickness Tol, in.
<10 ft . . . . 1/8 10–30 ft . . . . 1/4 >30 ft 1/2	0.004 in. per in. of width	0.050–0.0125 in./ft	<0.125 thk . . . . . 0.006 14–15 in. thk 0.080	0.005 in./in. of chord length	0.006–0.010

Sectioned Tubing

Tolerances on round tubing are usually given for outside and inside diameters, and wall thickness, and vary as a function of metal, composition, fabrication method (welded, drawn, extruded, etc.), and condition or temper (hot or cold finished). In addition, wall thickness tolerances may depend upon diameter and diameter tolerances may depend on wall. Although it is impossible to list tolerances here, in most cases the following general figures can be used: ±0.002 in. for small parts; ±0.008–0.025 in. for large parts

Roll Formed Parts

Length Tol, in.	Twist Tol	Angle Tol	Cross Section Tol, in.	Straightness Tol, in.
1/16	1/2 deg/ft (5 deg max)	1–2 deg (up to 0.125 in. thk)	0.002–0.015	1/8–1/2 (12-ft length)

Continuous Castings

Dimensional Tol, in.	Straightness Tol, in.	Machine Finish Allowance, in.	Surface Smoothness
<5 in. dia . . . . 0.005 >5 in. 1/64	<5 in. dia: 1/4 in. per 5 ft length	<5 in. dia . . . . 1/32–1/16 5–9 in. dia 3/32	Good

[d] Tolerances on diameters of shells to be drawn to a height 1/2–3/4 shell dia. Tolerances on irregular shapes are 20% higher.
[e] Ratio of inside cup diameter to blank diameter.
[f] For ferrous or bronze bearings.

Metal Forms—Typical Uses

Form ↓	General	Typical Parts
Sand Castings	Large and small complex parts in quantities too small to justify expensive tools and dies; also when metals stronger than zinc, aluminum and magnesium are required	Crankshafts, cylinder heads, manifolds, machine tool bases and housings, valves, fittings, dies, water pipe, hand tools, hardware, bearings, appliances, connecting rods, axles
Shell Mold Castings	Where cast finish and dimensional reproducibility are important, and where savings in machining offset added cost	Crankshafts, camshafts, gears, plumbing valves, hardware and fittings, small aircraft components
Permanent Mold Castings	Large quantities of parts where good finish, dimensional accuracy and minimum machining are required	Pistons, cylinder heads, washing machine agitators, bolts, cylinder blocks, gear blanks, flat iron base plates, bearings, levers, impellers, auto brake cylinders
Die Castings	High speed, large quantity production of intricate nonferrous parts requiring good surface finish and close dimensional tolerances	Optical equipment, automotive parts, motors, business machine parts, cooking utensils, typewriters, office equipment, aircraft instruments, pump impellers, gears, plumbing, switch parts, retainers
Plaster Mold Castings	Nonferrous parts in quantities too small to justify permanent molds, but large enough to outweigh machining costs of sand castings	Gears, ratchet teeth, cams, handles, small housings, pistons, wing nuts, locks, valves, hand tools, radar parts, etc. for aircraft, railroad, household, and electrical uses
Investment Castings	Large quantities of parts requiring excellent surface finish, intricate design, and close tolerances, especially for materials difficult to machine	Turbine blades, vanes, and wheels; aircraft manifolds, brackets, combustion chambers, struts; sewing machine parts; electrical equipment; military products; waveguides; hinges; numbering wheels; pawls; lock parts
Centrifugal Castings	Large, hollow, cylindrical forms with exceptional soundness and good dimensional accuracy	Pipe, rails, cylinder sleeves and liners, piston ring stock, bearings, bushings, pump parts, gear blanks, wheels, oil well equipment, pressure vessels, stator shells, reactor tubes
Open Die Forgings	Quantities too small to justify the cost of impression die tooling, or where sizes are too large or too irregular to be contained in impression dies	Weldless rings, axles, crankshafts, disks, gear blanks, pinion blanks, hooks, levers, nuts, spindles, valve stems, yokes
Closed Die Forgings	BLOCKER TYPE—Small quantities and additional machining is no serious problem CONVENTIONAL TYPE—Large quantities and limited or normal machining is desirable PRECISION TYPE—Large quantities and savings in material and machining are desirable	Crankshafts, hand tools, pistons, cylinder heads, propellers, valves, lock pins, plow disks, gears, pinions, springs, shafts, connecting rods, chains, bolts, wheel flanges, hardware and fittings, gear housings, aircraft fittings, auto and ship fittings, truck wheels, aircraft crankcases, business machine parts, torque and converter rotors, turbine wheels, structural parts for aircraft and missiles, nuclear reactors
Upset Forgings	Large quantities of symmetrical cylindrical parts	Axle shafts, pinions, valve stems, engine cylinders, worm gears, socket wrenches, special bolts and nuts, gear blanks, flanges, sleeves
Cold Headed Parts	High speed production of large quantities of relatively small symmetrical cylindrical parts	Originally, chiefly for bolts, nuts, rivets and other fasteners; now also for drawer pulls, electrical terminals, transformer studs, antifriction balls and rollers, business machine parts, automotive parts, capacitor plates
Impact (cold) Extruded Parts	Cup shapes where: 1) bottom must be considerably thicker than side walls; 2) bosses or projections are needed on bottom; 3) flanges are needed; and 4) length-to-diameter ratio exceeds 2:1	Cans of many shapes; flanged sleeves; anodes; brackets; aircraft fittings; automobile pistons; military projectiles, rocket motors and heads; hydraulic cylinders; differential gears; shock absorber cylinders; hub and axle components; piston pins; collapsible and rigid tubes

Metal Forms—Typical Uses

Form ↓	General	Typical Parts
Stampings, Drawn Parts	CUTTING—Large quantity production of relatively small, thin, flat shapes of varying complexity	Washers, links, bottle openers, key blanks, disks, laminations, brackets, gears, latches, escutcheons, jewelry, buttons, silverware, novelties, watch parts, business machine and typewriter parts
	FORMING—Sheet metal parts requiring flanges, curls, bends, embossing, coining, etc.	Handles, brackets, hinges, cooking utensils
	DRAWING—Large or small dished shapes	Cups, containers, drums, washing machine tubs, automobile body panels, aircraft fuselage and wing sections, pencil and pen caps, housings, cylinders, brake drums, tractor parts, cartridge shells, automobile fenders and hoods
Spinnings	Small runs (usually under 500 parts) of symmetrical shapes that are circular in cross section normal to the axis of rotation	Cooking utensils, light reflectors, tank heads, nose cones, thin-wall precision tubing, flanged-end tubular parts, drive shafts
Screw Machine Parts	High speed, low cost, quantity production of parts measuring from 0.005 to 2½ in. in dia and 6 in. long or less, and requiring close tolerances and good surface finish	Originally chiefly for screws, bolts and other threaded products; now used for practically any part with a surface of rotation concentric to the axis of the stock being turned
Powder Metallurgy Parts	Large quantities of parts that would otherwise be machined by methods other than automatic screw machine operations; or for short-run, complex parts where secondary operations can be eliminated; or where self-lubrication or tailored properties are desired	Self-lubricating bearings and mechanical or structural components, such as gears, cams, pawls, etc.; electrical contacts and brushes; friction materials; filters
Electroformed Parts	Parts requiring 1) extremely high surface smoothness, especially on internal contours; 2) absolute accuracy; and 3) intricate detail	Reflectors, propeller blades, tire molds, fountain pen barrels, radar and microwave components, waveguides, filters, antennas, missile nose cones, rocket thrust chambers, venturi nozzles, honeycomb sandwich, precision thin-wall tubing, phonograph record masters, molds for metal, plastic and ceramic forming
Cut Extrusions	Relatively small parts of uniform cross section that might otherwise be made only by extensive machining, or would require joining of several parts	Lock parts, camera bodies, aircraft wing spars, hinges, hose clamps, drawer pulls, flooring, tubing
Sectioned Tubing	Parts where 1) machining can be reduced (e.g., as replacement for bar stock for ring shapes); 2) deep drilling can be eliminated; or 3) higher structural strength is required than can be obtained with other methods	Bushings, seals, retainer rings, washers, liners, gaskets, spindles, cylinder containers, housings, sporting goods, gun parts, long thin-walled cylindrical shapes
Roll Formed Parts	Often competitive with extrusion, roll forming is generally selected for large quantity production of shapes that might require straightening if extruded	Rail car frames and exteriors; truck frames, siding, and flooring; aircraft framework; bicycle rims, fenders and frames; refrigerator cabinets and shelves; stove and washing machine parts; folding chairs; window and screen frames; building panels, siding, roofing gutters, downspouts; window blinds
Continuous Castings	Relatively complex bronze shapes that could only be made by extensive machining or a process requiring expensive dies	Bearings, bushings, gears, seals, sleeves, thrust washers, valve guides, wear strips, valve parts, pistons, tubular parts

Metal Forms—Cost Factors

Form ↓	Raw Materials	Tool and Die	Direct Labor	Finishing	Scrap Loss (waste)
Sand Castings	Low to medium—can be used in inexpensive form	Low	Low to high—much hand labor required	High—cleaning, snagging, machining	Moderate—scrap can usually be remelted
Shell Mold Castings	Low to medium	Low to moderate	Relatively low	Low—very little	Low—very little
Permanent Mold Castings	Medium—nonferrous metals primarily	Medium	Moderate	Low to moderate	Low—most scrap can be remelted
Die Castings	Medium—mostly zinc aluminum and magnesium	High—dies often more expensive than in any other casting process	Low to medium—offset by high production rate	Low—little more than trimming necessary	Low—can be remelted
Plaster Mold Castings	Medium—nonferrous metals only	Medium	High—skilled operators required	Low—little machining necessary	Low—most scrap is remelted
Investment Castings	High—process best suited to special, costly alloys	Low to moderate—depends upon availability of model	High—many hand operations necessary	Low—machining not usually necessary	Low—most scrap is remelted
Centrifugal Castings	Medium	Low—molds are relatively simple	Low to moderate	Low—little machining necessary	Low
Open Die Forgings	Medium	Very low	Medium to high—skilled labor needed	High—much material has to be removed	High—poor material utilization
Closed Die Forgings	Low to moderate	Low to high—blocker lowest, precision highest	Medium—skilled labor needed	Low to high—precision lowest, blocker highest	Low to high
Upset Forgings	Low to moderate	High—due to number of impressions	Medium—but lowest of forging methods	Medium—generally turning work	Moderate
Cold Headed Parts	Low to moderate—chiefly steel wire	Medium	Low—almost completely automatic	Low	Low—practically no scrap
Impact (cold) Extruded Parts	Moderate—primarily aluminum	Medium—depends on size and complexity	Low—little skilled labor needed	Low—often none	Low—practically none
Stampings, Drawn Parts	Low to medium—mostly carbon steel and copper	Medium to high—blanking dies are inexpensive, drawing dies more costly	Low to medium—depends on size and shape of part	Low—cleaning and trimming mostly	Medium to high—blanking scrap often high, but can be used for smaller parts
Spinnings	Low to moderate	Low	High—skilled craftsmen needed	Low—only cleaning and trimming	Moderate—most comes from cutting blanks
Screw Machine Parts	Low to medium—high alloys are expensive	Low	Low—one operator for several machines	Low—only cleaning and deburring	Low to high—depends on part design
Powder Metallurgy Parts	Low to high—iron powder is least costly	Low to high—depending upon complexity	Very low—largely automatic	Low—none required	Low—no scrap
Electroformed Parts	Low to high—from low cost iron to expensive precious metals	High—molds must be perfect	Medium to high—both skilled and unskilled labor needed	Low—no finishing needed	Low—little, if any scrap
Cut Extrusions	Medium—mostly aluminum and magnesium	Low to medium	Low—skilled labor not required	Low to medium—sections have to be cut	Low
Sectioned Tubing	High	Low—cutting done with simple tools	Low—skilled labor not required	Low—simple tumbling or deburring	Low—some machining required
Roll Formed Parts	Low to medium—mostly cold rolled steel	High—rolls are expensive	Low—automatic process	Low to medium—sections have to be cut	Low—practically none
Continuous Castings	Low to medium—primarily bronzes	Very low—among the lowest of all processes using dies	Low—automatic; skilled labor not required	Low to medium—straightening and cutting sections	Low—practically none

Wire Parts, Forms and Assemblies

Advantages. Wire forms, ranging from simple bent or ended wire to welded wire assemblies, are used in original design as well as to replace stampings, castings and forgings. In addition to the extreme design adaptability, wire forms offer economy, resiliency, lightness and decoration.

Materials. Although basic steel wire is used for the majority of wire forms, any material which can be drawn into wire may be used. Special types of steel wire include: galvanized (rust protection), Bethanized (rust and corrosion protection), coppered or tinned (attractive finish at low cost), spring wire (added stiffness and tensile strength), stainless steel (electropolished), and Copperweld, Nickelply and Copperply for special applications. Standard nonferrous metals include: monel, copper, bronze, brass and nickel silver. Special metals used are: aluminum, tungsten and molybdenum.

Sizes. Wire diameters from 0.035 in. (20 gage) to 0.375 in. (⅜ in.) are usually suitable for most wire form designs. Sizes as large as 0.5 in. or as small as 0.0015 in. are sometimes required. Etched wire is produced in sizes down to 0.00012 in.

Finishes. Wire products may be finished by electroplating, enameling or lacquering. The most popular plated finishes are: nickel, chromium, brass, cadmium and zinc. Special finishes include: anodized aluminum, plastics coating, and a black oxidized finish applied over zinc plate.

Parts and Forms. In addition to the parts and forms discussed below, drawings on this page illustrate standard wire end treatments.

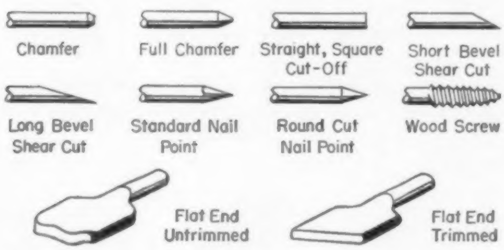
Eyes and ears—Eyes are formed in plain or teardrop shapes by plain or centered bends. Ears may be formed on one or both sides.

Upset pins—Standard pins are produced from wire of 0.010 to 0.125 in. dia, of any workable alloy and in various head shapes. If both a flange and head, or two or more flanges, are required, at least 0.070 in. spacing between adjacent faces is desirable.

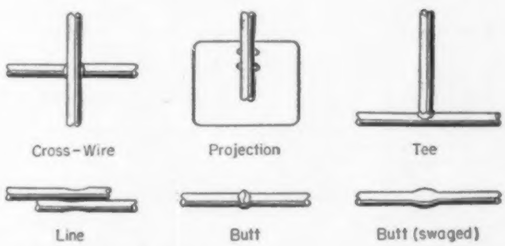
Wire threadings—Threads can be rolled or cut. Rolled thread has these advantages: less expensive; faster forming; no special fixtures; smaller dia wire required; chamfered end not necessary for easy starting. Cut thread has these advantages: stock size larger (or equal to) o.d. of thread; thread length not limited; can have chamfered end.

Formed rings—Rings may be formed on a wire ring coiler or a four-slide machine. Those formed on the slide machine do not butt perfectly; they are made from wire of 1/16 to 5/16-in. dia and in ring diameters of 1/2 to 2-in. i.d. Both flat and offset rings may be formed on the wire coiler. Wire diameter ranges from 1/16 to 5/16 in. and ring diameter from 5/8 to 3-in. o.d. Spiral rings are generally offset about one wire thickness.

Welded wire assemblies. For attaching wire together, or wire to strip, the most efficient operation is resistance spot welding. It is preferable that welds occur where two wires cross each other at right angles.



Wire end treatments



Welded wire joints

Typical wire forms and welded assemblies

Metal Mill Forms

Metal	Thickness Range, in.	Size Range (width x length), in.	Condition or Temper
FOIL			
Aluminum and Its Alloys	0.0002–0.0055	7–36 x 10–48; also rolls 3/8–66 x 48 in. in dia	Dead soft to full hard
Gold and Its Alloys	0.001–0.010	0.020–15.0 x 48 (max)	Soft to hard
Lead and Its Alloys	0.0003–0.006	22 max (width)	As rolled
Molybdenum	0.0025–0.004	12 x 36	Hot rolled, stress relieved
Palladium, Platinum	0.001–0.009	6 x 168 (max)	Soft to hard
Silver	0.001–0.010	0.020–15.0-in. wide coils	Soft to hard
Titanium and Its Alloys	0.001–0.010	24-in. wide coils (2000 lb max)	As cold rolled or annealed
Zirconium	0.0008 (min)	4-in. wide coils (5 lb max)	Cold rolled
STRIP			
Copper and Its Alloys	0.005–0.188	20-in. max (width)	Cold rolled
Gold and Its Alloys	0.001–0.062	0.062–15.0 x 12–96; 18-in. squares	Soft to hard
Nickel and Its Alloys	0.001–0.125	14-in. wide coils	Cold rolled; annealed
Palladium	0.001–0.040	0.062–15.0 x 12–96	Soft to hard
Platinum	0.010–0.125	10 x 72 (max)	Soft to hard
Silver	0.010–0.062	0.020–15.0 (width)	Soft to hard
Steel, Alloy	0.230–0.2477	23 15/16 max (width)	Cold rolled
	0.1799–0.2299	>6 to 23 15/16 (width)	Hot rolled; cold rolled
Steel, Carbon	<0.250	1/2–23 15/16 (width)	Cold rolled
	0.0255–0.2299	12 max (width)	Hot rolled
Steel, Stainless	<3/16	<24 (width)	Cold rolled
Zirconium	0.005–0.090	13-in. max width coils (1000 lb max)	Cold rolled; annealed
Zinc	0.004–0.374	3/16–20 (width)	Rolled
SHEET			
Aluminum and Its Alloys	0.006–0.249	3–120 x 36–360	Annealed; strain hardened
	0.010–0.249	3–120 x 36–360	Annealed; heat treated
Copper and its Alloys	0.010–0.188	20–60 (width)	Cold rolled
Gold and Its Alloys	0.010–0.125	0.020–15.0 x 72 (max); 18-in. squares	Soft to hard
Lead and Its Alloys	0.0117–1.000	48–144 x 12–540	As rolled
Magnesium and Its Alloys	0.016–0.249	24–48 x 96–144	Annealed; hard rolled
Molybdenum	0.005–0.1875	14–36 x 36–96	Hot rolled; stress relieved
Nickel and Its Alloys	0.018–0.250	60 x 144–178	Hot and cold rolled; annealed
Palladium	0.010–0.125	10 x 72 (max)	Soft to hard
Platinum	0.002–0.250	8–20 x 72 (max)	Soft to hard
Silver	0.010–0.062	0.020–15.0 x random lengths	Soft to hard
Steel, Alloy	0.180–0.2299	24–48 (width)	Hot rolled; cold rolled
	<0.1799	>48 (width)	Hot rolled; cold rolled
Steel, Carbon	0.0447–0.2299	12–48 (width)	Hot rolled
	0.0142–0.0821	>12 (width)	Cold rolled
Steel, Stainless	<3/16	24 and over (width)	Hot rolled; cold rolled
Titanium and Its Alloys	>0.010	48-in. max (width)	Annealed
Zirconium	0.090 (min)	48 x 120 (max)	Hot rolled; annealed
Zinc and Its Alloys	0.010–<0.500	3–61 x 3–144	Rolled
PLATE			
Aluminum and Its Alloys	0.250–3.000	2–132 x 12–540	Annealed; as fabricated; strain hardened; heat treated; stress relieved
Copper and Its Alloys	>0.188–2.000	>12–60 (width)	Cold rolled
Gold and Its Alloys	>0.125–0.500	6–15 x 36 (max); 18-in. squares	Soft to hard
Magnesium and Its Alloys	0.250–6.000	48 x 96–144	Annealed; hard rolled
Molybdenum	0.1875–1.500	36 x 72–132	Hot rolled; stress relieved
Nickel and Its Alloys	0.1875–4.000	10–150 (width)	Hot rolled; annealed; descaled
Palladium	>0.125	6 x 36 (max)	Soft to hard
Platinum	>0.100	6 x 36 (max)	Soft to hard
Silver	0.062–0.500	0.125–15.0-in. wide coils; 18-in. squares	Soft to hard
Steel, Alloy	0.2300 and over	>8–48 (width)	Hot rolled; heat treated
	0.1800 and over	>48 (width)	Hot rolled; heat treated
Steel, Carbon	0.2300 and over	>8–48 (width)	Hot rolled
	0.1800 and over	>48 (width)	Hot rolled
Steel, Stainless	3/16 and over	>10 (width)	Hot rolled; forged
Titanium and Its Alloys	—	72 x 144 (max)	Annealed
Zinc and Its Alloys	3/8–2.0	6–48 x 12–48	Rolled
Zirconium	1.000 (max)	48 x 120	Annealed; hot rolled
BAR			
Aluminum and Its Alloys	3/8–4.00 (square)	3/8–4 x 36–144	Annealed; as fabricated; strain hardened; heat treated
	3/8–3.00 (hex)	3/8–3 x 36–144	
	1/16–4.00 (rect)	3/8–10 x 36–144	
Copper and Its Alloys	>0.188–2.000	12-in. max (width)	Cold rolled
Gold and Its Alloys	0.500–1.000	1–4 x 12–48	Soft to hard

Metal Mill Forms

Metal ↓	Thickness Range, in.	Size Range (width x length), in.	Condition or Temper
Magnesium and Its Alloys	⅛–3.500	1–6 x 144	As extruded
Molybdenum	>$\frac{1}{16}$–3.500	120–144 (length)	Hot rolled; stress relieved; centerless ground
Nickel and Its Alloys	⅜–2¼ (square)	⅜–2¼ x 360	Hot rolled
	⅜–2½ (hex)	⅜–2½ x 360	Hot rolled
	2½–6(square forged)	2½–6 x 72	Forged
Palladium, Platinum	0.500 (max)	48-in. max (length)	Soft to hard
Silver	0.500–1.000	1–4 x 12	As cast; as machined
Steel, Alloy	< $\frac{5}{16}$–9½ (square); < ½–3½ (hex)	< 1–6 (width)	Hot rolled
	< $\frac{5}{16}$–4 (square); < $\frac{5}{16}$–3⅛ (hex)	< ¾–12 (width)	Cold finished
Steel, Carbon	¼–6(square); ⅜–4$\frac{1}{16}$(hex)	6 max (width)	Hot rolled
Steel, Stainless	¼–8 (square) ¼–3½ (hex, oct)	¼–10 (width)	Hot finished
	>½	>⅜ (width)	Cold finished
Zirconium	⅜ (min)	144–300 (length)	Hot rolled; annealed

Metal ↓	Diameter Range, in.	Length Range, in.	Condition, Temper
ROD			
Aluminum and Its Alloys	⅜–8.00	36–144	Annealed; as fabricated; strain hardened; heat treated
Bronze	½–9⅛	105 (max)	Continuous cast
Copper and Its Alloys	¼ – >3.00	72–168	Hot rolled
Gold and Its Alloys	⅛–2.00	1–120	Soft to hard
Magnesium and Its Alloys	¼–9.00	144	Extruded
Molybdenum	⅛–⅜	144–168	Hot swaged; stress relieved; centerless ground
Nickel and Its Alloys	$\frac{1}{16}$–4.00	456 (max)	Cold drawn
	¼–4.50	288 (max)	Hot finished
	12–25	—	Forged billets
Palladium, Platinum	⅛–⅜	1–120	Soft to hard
Silver	0.1875–2.00	1–120	Soft to hard up to 1 in.; >1 in., as cast
Steel, Alloy	$\frac{7}{32}$ and over	Coils	Hot rolled; heat treated
Steel, Carbon	$\frac{7}{32}$–4$\frac{7}{64}$	Coils	Hot rolled
Steel, Stainless	¼–¾	Coils	Hot rolled
Titanium and Its Alloys	—	144	Annealed
Zirconium	$\frac{5}{16}$ (min)	35-lb coils	Hot rolled; annealed

Metal ↓	Diameter Range, in.	Length Range, in.	Condition, Temper
WIRE (round)			
Aluminum and Its Alloys	0.010–0.374	5, 15, 200-lb spools	Annealed; as fabricated; strain hardened; heat treated
Copper and Its Alloys	0.010–0.750	—	—
Gold and Its Alloys	0.003–0.1875	1 in. to 1000-ft coils	Soft to hard
Molybdenum	$\frac{1}{16}$–⅛	1000-ft coils; 10–12-ft cut lengths	Hot swaged; drawn; seal ground
Nickel and Its Alloys	¼–⅞	Coils	Hot rolled
	0.001–0.875	Coils	Cold drawn
Palladium	0.003–0.125	1 in. to 100-ft coils	Soft to hard
Platinum	0.001–0.125	Coils	Soft to hard
Silver	0.003–0.1875	Coils	Soft to hard
Steel, Alloy	0.020–0.099	Coils	—
Steel, Carbon	0.004–0.625	Coils	—
Steel, Stainless	0.003–0.500	Coils	—
Titanium	0.045 (min)	Coils; 12-ft cut lengths	Annealed
Zirconium	0.010–0.200	25-lb coils (max); 5-ft cut lengths	Cold drawn; vacuum annealed

Metal ↓	O.D. Range, in.	Wall Thickness Range, in.	Length Range, in.	Condition, Temper
TUBE (round)				
Aluminum and Its Alloys	⅛–14.0	0.014–0.500	72–720	Extruded; annealed; strain hardened; heat treated
Bronze	½–9⅛	⅛ (min)	105 (max)	Continuous cast
Copper and Its Alloys	⅛–12.0	0.010–⅝	—	—
Gold and Its Alloys	0.010–1.000	0.002–0.080	1–240	Soft to hard
Lead and Its Alloys	⅜–13	½ (max)	—	—
Magnesium and Its Alloys	½–4.000	0.065–0.250	144	Extruded
Nickel and Its Alloys	0.012–8.000	0.002–0.500	>360	Cold drawn
	2½–9¼	¼–1.000	36–384	Extruded
Palladium, Platinum	0.010–0.500	0.003–0.042	1–120	Soft to hard
Silver	0.020–1.000	0.002–0.080	240 (max)	Soft to hard
Steel, Alloy	$\frac{3}{16}$–10¾	0.022– >0.203	—	Hot or cold finished
Steel, Carbon	$\frac{3}{16}$–10¾	0.028–0.250	—	Hot or cold finished
Steel, Stainless	< ½–8⅝	< 0.15–< 0.300	—	Hot or cold finished
Zirconium	¼–2.00 (i.d.)	0.020–$\frac{3}{16}$	240 (max)	One quarter to full hard; annealed

Patterned Sheet Metal

Type ➜	Coined	Embossed	Perforated	Expanded
How Obtained	Cold rolling with male or female pattern engraved on hardened, forged steel roll and impressed on one side of sheet only	Cold rolling with male pattern engraved on one steel roll and matching female pattern on other, i e, pattern is impressed three-dimensionally	High speed stamping or punching operation	Spitting and cold drawing in continuous patterns
Advantages	Hide marks, blemishes, scratches; reduce friction on slides, etc.; less costly than Embossed	Advantages of Coined sheet plus increased strength by redistribution of metal (see below); increased surface for heat transfer applications	Allow passage of air and light; visibility for inspection of enclosure; inexpensive	Advantages of Perforated, plus increased strength and possibility of more varied patterns
Remarks	No strong evidence of increased mechanical properties; often used for decorative strip with complex pattern design	Some patterns increase rigidity as much as 108%, impact resistance 39% and yield strength 92%	Mechanical strength decreased; formability increased	Openings can be varied from 1/16 to 4 in. to suit function and appearance
Materials	Steel, aluminum, stainless steel in sheet and strip. Copper, bronze, brass, nickel silvers in strip	Mostly stainless steel, low carbon steel, and aluminum alloys. Some strip in copper alloys; some titanium	Mostly low carbon steel, aluminum and tin	Aluminum, steel, stainless steel, monel, copper, brass
Sizes	Sheet: 18 to 72 in. x 6 to 24 ft x 0.025 to 0.125 in. Strip: 4 to 6.5 in. x 0.010 to 0.093 in.	5 to 52 in. x 6–16 ft x 0.018 to 0.250 in.	Steel: 16 to 26 gage; 36 x 96 to 48 x 120 in. Aluminum: 14 and 18 gage; 36 x 96 and 36 x 120 in.	14 to 28 gage; 36 x 72 to 48 x 120 in.
Patterns	Unlimited; mostly fluted, pebbled, stippled, ribbed, and stucco. Depth ranges from 0.002 to 0.015 in., generally about 0.007 in.	Large variety; mostly wood or leather grained, diamond, square, and same as coined. Depth ranges from 0.002 into corrugated patterns	Round holes and rounded end slots parallel either to width or length	Almost all diamond-shaped patterns but some woven or wire-fence type patterns
Uses	Decorative applications; materials handling slides; appliance, architectural and furniture trim; jewelry; fish lures	Same as Coined; heat exchangers; fluid transmission units; applications requiring greater strength than Coined	Decorative applications; ventilating panels and covers; guards; baskets; partitions and trim	Same as Perforated; grills; sound absorbent units; enclosures; automotive and aircraft uses requiring strength

"Patterned" is used here to include coined, embossed, perforated and expanded sheet and strip.

Advantages. Essentially the materials are intended for decorative use. In the case of flat sheet metal used over a large area, they prevent kinking and "oil-canning." They also diffuse light, eliminating harsh highlights on polished materials, or telltale highlights on distorted materials. In some cases they provide added strength and rigidity, or allow the use of lighter gage stock. Any changes in mechanical properties depend on the particular process, material and pattern.

Finishes. Most sheet metal products must be finished after fabrication, usually by some type of polishing or coating. The same end result can often be achieved more economically by using patterned sheet instead. Broad decorative and protective possibilities can also be achieved by judicious use of coatings over patterns. Colored textured metal is an outstanding example; the color may be applied by coating with pigment and baking, or by vacuum metallizing.

Design Rules. Patterned metals can be fabricated with standard tooling used for flat sheet metals. Depending on the alloy used, the materials can be blanked, punched, formed, stamped, moderately drawn, roll formed, lock-seam joined, riveted, soldered and welded.

Only for embossed sheet is any modification of standard techniques required:

1. Die clearance should be adjusted for cross-sectional thickness.

2. Bend radii should be at least twice the cross-sectional thickness unless bend lines fall along apexes of the design.

3. For severe bends the axis of bend should run at right angles to the pattern direction.

4. Draws under 1 in. will not usually cause pattern distortion, but actual depth of draw possible depends on pattern.

5. For resistance welding, copper wire braid can be laid between electrode and embossed pattern to form a nest.

Plastics & Rubber Forms—Process, Advantages, Limitations

Form ↓	The Process	Advantages	Limitations
PLASTICS			
Injection Moldings	Similar to die casting of metals. A thermoplastic molding compound is heated to plasticity in a cylinder at a controlled temperature and then forced under pressure through sprues, runners and gates into a cool mold; the resin solidifies rapidly, the mold is opened, and the parts ejected; with certain modifications, thermosetting materials can be used for small parts	Extremely rapid production rate and hence low cost per part; little finishing required; excellent surface finish; good dimensional accuracy; ability to produce variety of relatively complex and intricate shapes	High tool and die costs; high scrap loss; limited to relatively small parts; not practical for small runs
Cut Extrusions	Thermoplastic molding powder is fed through a hopper to a chamber where it is heated to plasticity and then driven, usually by a rotating screw, through a die having the desired cross section; extruded lengths are either used as-is or cut into sections; with modifications, thermosetting materials can be used	Very low tool cost; material can be placed where needed; great variety of complex shapes possible; rapid production rate	Close tolerances difficult to achieve; openings must be in direction of extrusion; limited to shapes of uniform cross section (along length)
Sheet Moldings (thermoforming)	VACUUM FORMING—Heat-softened sheet is placed over a male or female mold; air is evacuated from between sheet and mold, causing sheet to conform to contour of mold. There are many modifications, including vacuum snapback forming, plug assist, drape forming, etc.	Simple procedure; inexpensive; good dimensional accuracy; ability to produce large parts with thin sections	Limited to parts of low profile
	BLOW OR PRESSURE FORMING—Actually the reverse of vacuum forming in that positive air pressure rather than vacuum is applied to form sheet to mold contour	Ability to produce deep drawn parts; ability to use sheet too thick for vacuum forming; good dimensional accuracy; rapid production rate	Relatively expensive; molds must be highly polished
	MECHANICAL FORMING—Sheet metal equipment (presses, benders, rollers, creasers, etc.) forms heated sheet by mechanical means. Localized heating is used to bend angles; where several bends are required, heating elements are arranged in series	Ability to form heavy and/or tough materials; simple; inexpensive; rapid production rate	Limited to relatively simple shapes
Blow Moldings	An extruded tube (parison) of heated plastics is placed within the two halves of a female mold and expanded against the sides of the mold by air pressure; the most common method uses injection molding equipment with a special mold	Low tool and die cost; rapid production rate; ability to produce relatively complex shapes in one piece	Limited to hollow or tubular parts; choice of materials limited; poor dimensional accuracy
Slush Moldings	Liquid material (usually vinyl plastisol or organosol) is poured into a closed mold, the mold is heated to fuse a specified thickness of material adjacent to mold surface, excess material is poured out, and the semi-fused part placed in an oven for final curing. A variation, rotational molding, provides completely enclosed hollow parts	Low cost molds; relatively high degree of complexity; little shrinkage	Relatively slow production rate; choice of materials limited
Compression Moldings	A partially polymerized thermosetting resin, usually preformed, is placed in a heated mold cavity; mold is closed, heat and pressure applied, and the material flows and fills mold cavity; heat completes polymerization and mold is opened to remove hardened part. Method is sometimes used for thermoplastics, e.g., vinyl phonograph records; in this operation, the mold is cooled before it is opened	Little waste of material and reduced finishing costs due to absence of sprues, runners, gates, etc.; large, bulky parts possible	Extremely intricate parts involving undercuts, side draws, small holes, delicate inserts, etc., not practical; extremely close tolerances difficult to achieve
Transfer Moldings	Also used primarily for thermosetting materials, this method differs from compression molding in that the plastic is 1) first heated to plasticity in a transfer chamber, and 2) fed, by means of a plunger, through sprues, runners and gates into a closed mold	Thin sections and delicate inserts are easily used; flow of material is more easily controlled than in compression molding; good dimensional accuracy; rapid production rate	Molds are more elaborate than compression molds, and hence more expensive; loss of material in cull and sprue; size of parts somewhat limited
Reinforced Plastics Moldings	CONTACT—The lay-up, which consists of a mixture of reinforcement (usually glass cloth or fibers) and resin (usually thermosetting), is placed in mold by hand and allowed to harden without heat or pressure	Low cost; no limitations on size or shape of part	Parts are sometimes erratic in performance and appearance; limited to polyesters, epoxies and some phenolics

continued on next page

Plastics & Rubber Forms—Process, Advantages, Limitations

Form	The Process	Advantages	Limitations
PLASTICS			
Reinforced Plastics Moldings (cont'd)	VACUUM BAG—Similar to contact except a flexible polyvinyl alcohol film is placed over lay-up and a vacuum drawn between film and mold (about 12 psi)	Greater densification allows higher glass contents resulting in higher strengths	Limited to polyesters, epoxies and some phenolics
	PRESSURE BAG—A variation of vacuum bag in which a rubber blanket (or bag) is placed against film and inflated to apply about 50 psi	Allows greater glass contents	Limited to polyesters, epoxies and some phenolics
	AUTOCLAVE—The vacuum-bag setup is simply placed in an autoclave with hot air at pressures up to 200 psi	Better quality moldings	Slow rate of production
	MATCHED DIE—A variation of conventional compression molding, this process uses two metal molds which have a close-fitting, telescoping area to seal in the resin and trim the reinforcement; the reinforcement, usually mat or preform, is positioned in the mold, a premeasured quantity of resin is poured in, and the mold is closed and heated; pressures generally vary between 150 and 400 psi	Rapid production rates; good quality and excellent reproducibility; excellent surface finish on both sides; elimination of trimming operations; high strength due to very high glass content	High mold and equipment costs; complexity of part is restricted; size of part limited
	FILAMENT WOUND—Glass filaments, usually in the form of rovings, are saturated with resin and machine wound onto mandrels having the shape of desired finished part; finished part is cured at either room temperature or in an oven, depending on resin used and size of part	Provides precisely oriented reinforcing filaments; excellent strength-to-weight ratio; good uniformity	Limited to shapes of positive curvature; drilling or cutting reduces strength
	SPRAY MOLDING—Resin systems and chopped fibers are sprayed simultaneously from two guns against a mold; after spraying, layer is rolled flat with a hand roller. Either room temperature or oven cure	Low cost; relatively high production rate; high degree of complexity possible	Requires skilled workers; lack of reproducibility
Castings	Plastic material (usually thermosetting except for the acrylics) is heated to a fluid mass, poured into mold (without pressure), cured, and removed from mold	Low mold cost; ability to produce large parts with thick sections; little finishing required; good surface finish	Limited to relatively simple shapes
Cold Moldings	Method is similar to compression molding in that material is charged into a split, or open, mold; it differs in that it uses no heat—only pressure. After the part is removed from mold, it is placed in an oven to cure to final state	Because of special materials used, parts have excellent electrical insulating properties and resistance to moisture and heat; low cost; rapid production rate	Poor surface finish; poor dimensional accuracy; molds wear rapidly; relatively expensive finishing; materials must be mixed and used immediately
RUBBER			
Compression Moldings	An excess amount of uncured compound is placed in mold cavity; mold is closed and heat and pressure applied, forcing compound to fill mold cavity; heat cures (vulcanizes) compound and mold is opened to remove hardened parts	Good surface finish; parts can be made in almost any hardness, shape and size; relatively low cost; little waste; most compounds suitable	Close tolerances difficult to achieve; flash has to be removed; extreme intricacy difficult; slow production rate
Transfer, Injection Moldings	Similar to compression molding except that mold is closed empty and rubber compound is forced into it through sprues, runners and gates. Rubber injection molding differs from plastics injection molding in that rubber is injected into hot molds	Very good dimensional accuracy; no flash removal; ability to produce extremely intricate parts; good finish and uniformity; rapid production rate	High mold costs; not all rubber compounds can be used; high scrap loss due to sprues, runners, etc.
Cut Extrusions	Similar to plastic extrusion in that heated material is forced through a die having desired cross section. However, vulcanization does not take place in mold cavity; extruded lengths are cured in a steam vulcanizer and either used as-is or cut into sections (usually on a lathe)	Very low cost operation; great variety of complex shapes possible; rapid production rate	Close tolerances difficult to achieve; limited to parts of uniform cross section (along length); openings must be in direction of extrusion
Die Cut Parts	Stamped or cut from vulcanized sheet or slab with inexpensive steel dies	Practically any rubber material can be cut in almost any size; low cost; economical for small quantities	Thickness of part is limited; limited to flat parts

Plastics & Rubber Forms—Choice of Materials[a]

PLASTIC →	ABS	Acetal	Acrylics	Alkyds	Cellulose Acetate	Cellulose Acetate Butyrate	Cellulose Propionate	Chlorinated Polyether	Diallyl Phthalate	Epoxy	Ethyl Cellulose	TFE Fluorocarbon	CFE Fluorocarbon	Melamine	Nylon	Phenolic	Polycarbonate	Polyester	Polyethylenes	Polypropylene	Polystyrenes	Silicone	Urea	Vinyls (rigid)	Vinyls (nonrigid)
Injection Moldings	▣	▣	▣		▣	▣	▣	▣			▣		▣		■		▣		■	▣	■				▣
Cut Extrusions	▣	▣	■		▣	■	▣	▣			▣		▣		■		▣		■	▣	■			■	■
Sheet Moldings (thermoforming)	▣		■		■	▣	▣				▣	▣	▣		▣				▣	▣	■			▣	■
Blow Moldings		▣			▣	▣									▣				■	▣					
Slush Moldings																								▣	■
Compression Moldings	▣		▣	■	▣	▣	▣		■	▣	▣	▣	▣	■	▣	■		■	▣		▣	▣	■	■	
Transfer Moldings				▣					▣	▣				■		■		▣				▣	▣		
Reinforced Plastics Moldings: Low Pressure										■						■		■							
Reinforced Plastics Moldings: Matched Die				▣					▣	■				▣		■		■				▣			
Reinforced Plastics Moldings: Filament Wound										■								▣							
Reinforced Plastics Moldings: Spray										■								■							
Castings			■							■						■		■	▣			▣			▣
Cold Moldings[b]																▣									

RUBBER[c] →	Styrene Butadiene (SBR)	Butyl (IIR)	Nitrile (NBR)	Neoprene (CR)	Silicone	Acrylate	Chlorosulfonated Polyethylene (Hypalon)	Urethane	Fluoroelastomers (Viton)	Natural Rubber	Hard Rubber
Compression Moldings	■	▣	■	■	▣	▣	▣	▣	▣	■	▣
Transfer, Injection Moldings	■	▣	■	■	▣	▣	▣	▣	▣	■	▣
Cut Extrusions	■	▣	■	■	▣	▣	▣	▣	▣	■	▣
Die Cut Parts	■	▣	■	■	▣	▣	▣	▣	▣	■	▣

[a] ■ = Materials most frequently used.
▣ = Materials currently being used.
[b] Special materials classified as nonrefactory (organic) and refactory (inorganic); organic types consist of binders (asphalts, oils, resins, etc.) and fillers (asbestos fibers, silica compounds, etc.); inorganic types consist of binders (cement, lime, etc.) and fillers (asbestos).
[c] Polysulfide rubber (Thiokol) is available for casting.

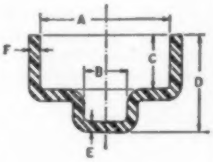
Plastics & Rubber Forms—Complexity of Part

Form ↓	Section Thickness, in. Max	Section Thickness, in. Min	Bosses	Undercuts	Inserts	Holes
PLASTICS						
Injection Moldings	>1.0; normally 0.250	0.015	Yes	Possible—but undesirable; reduce production speed and increase cost	Yes—variety of threaded and non-threaded	Yes—both through and blind
Cut Extrusions	0.50	0.010	Yes	Yes—no difficulty	Yes—no difficulty	Yes—in direction of extrusion only; 0.020–0.040 in. min
Sheet Moldings (thermoforming)	3.0[a]	0.00025[b]	Yes	Yes—but reduce production rate	Yes	No
Slush Moldings	—	0.020	Yes	Yes—flexibility of vinyl allows drastic undercuts	Yes	Yes
Compression Moldings	—	0.035–0.125	Possible	Possible—but not recommended	Yes—but avoid long, slender, delicate inserts	Yes—both through and blind; but should be round, large, and at right angles to surface of part
Transfer Moldings	—	0.035–0.125	Possible	Possible—but should be avoided; reduce production rate	Yes—delicate inserts may be used	Yes—should be round, large, and at right angels to surface of part
Reinforced Plastics Moldings	Bag: 1.0; matched die: ¼	Bag: 0.10; matched die: 0.03	Possible	Bag: yes; matched die: no	Bag: yes; matched die: possible	Bag: only large holes; matched die: yes
Castings	—	⅛–³⁄₁₆	Yes	Yes—but only with split and cored molds	Yes	Yes
RUBBER						
Compression Moldings	16.0	¹⁄₆₄	Yes	Yes—no difficulty on parts <60 durometer	Yes—but avoid long, slender inserts	Yes
Transfer, Injection Moldings	4–6	0.005	Yes	Possible—but should be avoided	Yes—incl long, delicate inserts	Yes
Cut Extrusions	4	¹⁄₁₆	Yes	Yes	Yes—no difficulty	Yes—in direction of extrusion only
Die Cut Parts	1.0; usually <¾	³⁄₃₂	No—unless on sheet being cut	No	No	Yes—no difficulty if dia is >½t

[a] Cast sheet thickness. [b] Film thickness.

Plastics & Rubber Forms—Dimensional Characteristics[a]

PLASTICS



Form		Length, Dia, and Depth Tolerances (A, B, C), in. 1 IN.	3 IN.	6 IN.[d]	Height Tol (D), in.[b]	Bottom Wall Tol (E), in.[c]	Draft Allowance, deg
Injection Moldings	Cellulosics	0.003 –0.004	0.005–0.006	0.008	0.005–0.006	0.004–0.009	¼–½
	Polyethylenes	0.006 –0.075	0.009–0.011	0.013–0.015	0.006–0.007	0.004–0.008	¾–1
	Polystyrenes	0.0035–0.0045	0.005–0.007	0.007–0.010	0.004	0.003–0.009	½
	Nylons	0.006	0.0085	0.0125	0.007	0.006–0.009	½
	TFE	0.0065	0.011	0.016	0.010	0.005–0.007	1
	Vinyls	0.055 –0.007	0.007–0.009	0.009–0.012	0.005	0.003–0.006	½
Compression, Transfer Moldings	Phenolics	0.004 –0.006	0.006–0.009	0.009–0.014	0.008–0.012	0.005–0.006	¼–½
	Ureas	0.005 –0.007	0.008–0.011	0.011–0.017	0.006–0.010	0.004–0.006	¼–½
	Melamines	0.005 –0.006	0.008–0.010	0.012–0.018	0.007–0.010	0.004–0.006	¼–½
	Alkyds	0.002 –0.005	0.003–0.006	0.004–0.0085	0.002–0.006	0.004–0.006	¼–½
Cold Moldings		0.008 –0.012	0.012–0.018	0.018–0.028	0.016–0.024	0.010–0.012	½–1
Cut Extrusions	Tolerances on all dimensions except channel openings are ±0.01; on channel openings in a flexible material, tolerances are ±0.02–0.03. Tolerances on extruded tubing: on dia up to 1/10, ±0.002; dia up to ¼, ±0.003; dia up to ½, ±0.005; dia over ½, ±0.01						

RUBBER

Compression, Transfer Moldings	Size, in.	Class 1 (precision): Dimensions Not Affected by Flash	Class 1 (precision): Dimensions Measured Across Flash	Class 3 (commercial): Dimensions Not Affected by Flash	Class 3 (commercial): Dimensions Measured Across Flash
	0.000–0.499	0.003	0.005	0.010	0.015
	0.500–0.999	0.005	0.008	0.010	0.018
	1.000–1.999	0.008	0.010	0.015	0.020
	2.000–2.999	0.010	0.013	0.020	0.025
	3.000–3.999	0.013	—	0.025	0.030
	4.000–4.999	0.015	—	0.030	0.035
	5.000–7.999	0.020	—	0.045	0.050

	Cross-Sectional Dimension, in.	Tolerance		Thickness, in.	Tolerance
Cut Extrusions	0–¼	1/64	**Die Cut Parts**	¼–1/32	0.008
	½–½	1/32		1/16–⅛	0.016
	½–1	3/64		5/32–⅜	0.031
	1–2	1/16		½ and over	0.047

[a] Tolerances are for usual commercial practice, stated for guide only. In most cases, closer tolerances can be held at increased cost. Tolerances are overall; all values are ± unless otherwise stated.
[b] Tolerances on dimensions up to 1 in. in multicavity molds. For dimensions greater than 1 in., add 0.003–0.005 in/in. for compression moldings, 0.002–0.004 for injection moldings. Transfer molding tolerances are approximately 0.003 in. lower than those for compression moldings.
[c] For dimensions from 0.1 to 0.3 in. Side wall tolerances (F) are approximately 0.005–0.007 in.
[d] Tolerances on dimensions over 6 in. increase by as much as 0.002–0.010 in./in.

Plastics & Rubber Forms—Typical Uses

Form ↓	General	Typical Parts
PLASTICS		
Injection Moldings	High speed, large quantity production of relatively close tolerance, intricate thermoplastic parts	Cases and housings for radios, etc.; refrigerator and auto parts; handles; gears; impellers; plumbing and hardware; appliance parts; auto tail lights and medallions; buttons; toys; shoe heels; telephone handsets; steering wheels; pen and pencil barrels; refrigerator breaker strips; bearings; valve and pump parts; coil forms; fasteners; fittings; house wares; heads for garden hose; fan blades; grilles
Cut Extrusions	Thermoplastic parts requiring uniform cross section, undercuts, or small holes that would otherwise have to be molded or machined from bar stock; also, for tubular parts	Edgings, trim, retainers, joint and panel moldings, clips and holding devices, nameplate holders, magnifying strips, handle parts, light shields, sliding door tracks, gaskets, pen and pencil parts, refrigerator breaker strips, fluid lines
Sheet Moldings (thermoforming)	Low or medium quantity production of thermoplastic parts having large areas in relation to their cross section and thin walls; also, for deep drawn parts requiring detail, undercuts and inserts	Automobile dash boards, door panels, tail lights; aircraft canopies and windshields; signs, displays, light fixtures; packaging units; housewares; toys; television tube masks; furniture drawers; trays; refrigerator parts; luggage; instrument panels; skylights
Blow Moldings	One-piece hollow thermoplastic parts	Bottles, carboys, containers, automobile heater ducts, traffic blinker housings, packaging units, ping pong balls, baby rattles, Christmas tree ornaments, atomizer bulbs, floats
Slush Moldings	Hollow, flexible thermoplastic parts requiring intricate detail and good dimensional accuracy	Dolls and doll parts, soft toys, bicycle seats
Compression Moldings	Large and small thermosetting parts not requiring extremely close tolerances, delicate inserts or intricate design; especially suited to parts of large area or deep draw	LARGE PARTS—Housings, switch bases, furniture drawers, automobile body panels, radio and television cabinets, washing machine agitators, etc. SMALL PARTS—Closures, tube bases, buttons, wiring devices, dials, knobs, handles, dinnerware
Transfer Moldings	Relatively small thermosetting parts requiring close dimensional tolerances, deep holes, thin sections, delicate inserts, and fairly intricate design	Automobile distributor heads, camera and projector parts, switch parts, electrical parts, buttons, closures, coil forms
Reinforced Plastics Moldings	Relatively large structural parts requiring a high strength-to-weight ratio	Large scrubber tanks, truck cabs, chemical tanks, aircraft luggage pods, torpedo launching tubes, ground radomes, pressure vessels, rocket motor sections, boat hulls, automobile bodies, luggage, pipe, aircraft components, interior partitions, skylights, translucent roofing
Castings	Low cost, relatively simple thermosetting (except for acrylic) parts requiring good finish and not requiring close dimensional tolerances; used most often when the number of parts does not justify expensive dies	Rods, tubes, cylinders, sheet, and slabs for further fabrication into various shapes; small radio cabinets; jewelry and ornamental objects; knobs; clock and instrument cases; handles; drilling jigs; missile components; buckles; buttons; lamp bases; drawer pulls; acrylic sheet and lenses; and for potting and encapsulating
Cold Moldings	Relatively complex parts requiring excellent heat resistance and electrical insulating properties	Switch bases and plugs, arc barriers and shoots, third rail insulations, small gears, handles, knobs, tiles, furnace covers, jigs and dies
RUBBER		
Compression Moldings	Relatively short runs of large parts not requiring extremely close tolerances where other methods would be too expensive	Engine mountings, bumpers, boots, bellows, diaphragms, sealing rings, packings, shock absorbers, shoe heels, railroad car parts
Transfer, Injection Moldings	Relatively small parts requiring close dimensional tolerances, deep holes, thin sections, delicate inserts, and fairly intricate design	Hydraulic brake parts, diaphragms, electrical parts, valve seats and closures, seals, o-rings
Cut Extrusions	Parts not requiring extremely close tolerances, but requiring uniform section, undercuts, and holes where other methods would be too expensive; also, for tubular parts	Gaskets, weatherstrip, glass channels, slides, tire tread, inner tubes, belts, hose
Die Cut Parts	Flat, thin parts	Flat gaskets, disks, spacers, packings

Plastics & Rubber Forms—Cost Factors

Form ↓	Raw Materials	Tool and Die	Direct Labor	Finishing	Scrap Loss
PLASTICS					
Injection Moldings	Low to high—from low cost polystyrene to high cost acetal and polycarbonate	Medium to high—rapid cycle reduces number of cavities required	Low—high rate of production reduces cost per part; fully automatic	Low—major operation is degating, but is often automatic operation	Low—loss of material in sprues, runners, gates, etc., but most can be reused
Cut Extrusions	Low to high—from low cost polystyrene to high cost acetal and polycarbonate	Very low	Low—fully automatic	Low—only cutting of sections	Low—small waste on cut lengths
Sheet Moldings (thermoforming)	Medium to high—sheet materials more costly than molding compounds	Low—not as elaborate as injection or compression molds	Low to medium	Medium—excess flange must be trimmed; secondary operations often required	Low to medium
Blow Moldings	Low—mostly polyethylene	Low to medium—depends on type of mold used	Medium to high—depends on production method	Low	Low
Slush Moldings	Low to medium—depends on specific formulation of vinyl plastisol used	Low—molds generally consist of electrodeposited copper on a wax model	Low—conveyorized systems require only pouring of material	Low—no parting lines	Low—unfused material in mold is reused
Compression Moldings	Low to medium—mostly low cost phenolic; also urea and melamine	Medium to high—usually less expensive than transfer molds	Low—automatic presses require little supervision	Low to medium—no gates to remove, but considerable flash	Low to medium—no sprues, runners or gates, but considerable flash
Transfer Moldings	Low to medium—mostly low cost phenolic; also urea and melamine	Medium to high—normally higher than compression molds due to greater complexity	Low—automatic presses require little supervision	Low—no flash to remove; degating easily accomplished	Medium—loss of material in cull, sprue and runners, but no flash
Reinforced Plastics Moldings	Low to high—polyesters (most often used) are inexpensive; epoxies and silicones fairly expensive	Low to high—from inexpensive plaster and plastics molds to relatively expensive steel and aluminum molds	High to medium—hand layup is relatively expensive	Low to high	Medium
Castings	Low to medium—mostly phenolic (inexpensive) and epoxy (expensive)	Low	High	Low—usually only removal of flash	Low to medium
Cold Moldings	Low—materials plentiful and inexpensive	Medium to high—requires special steels to resist abrasive action of raw materials	Low	Medium—flash, fins must be removed	Low to medium
RUBBER					
Compression Moldings	Low to medium	Medium—generally less expensive than for transfer molding	High—requires hand loading of mold cavities	Medium—flash has to be removed	Medium—only flash
Transfer, Injection Moldings	Low to medium	High—complex molds are expensive	Low—semi-automatic operation	Low—no flash removal	High—sprues, runners, gates, etc.
Cut Extrusions	Low to medium	Low	Low	Low—just cutting sections	Low—small waste on cut lengths
Die Cut Parts	Low to medium	Low to medium	Low to high—depends on hand or automatic	Low—practically none	Low to high—depends on shape of part

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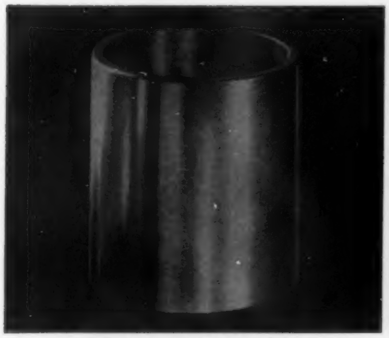

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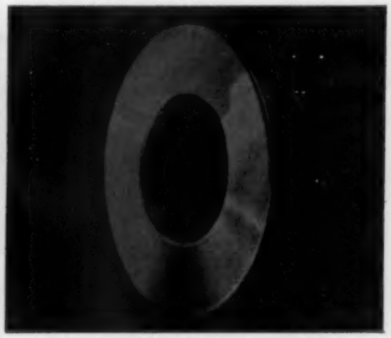

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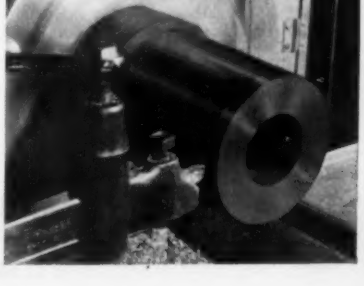

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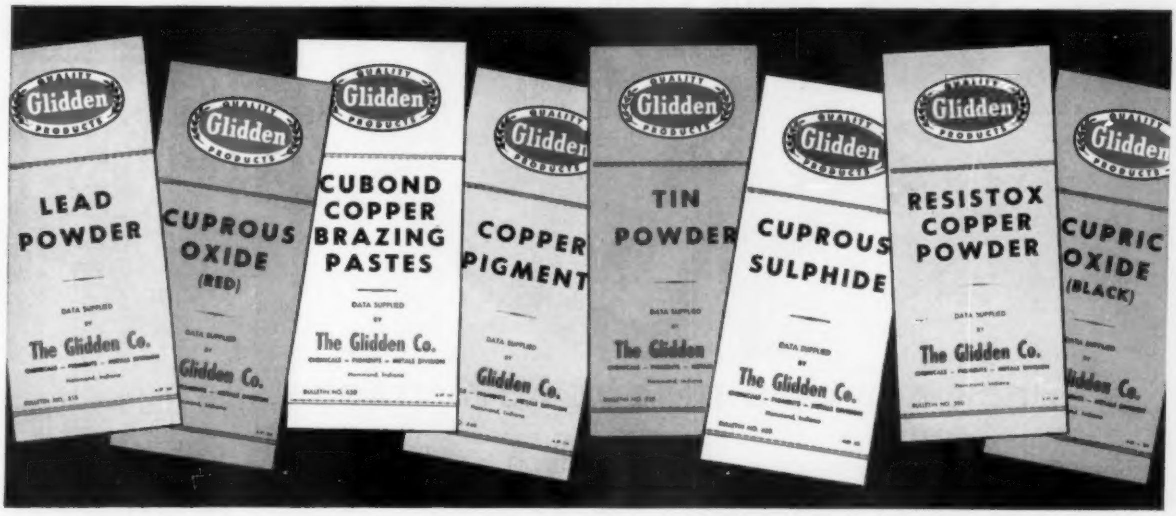

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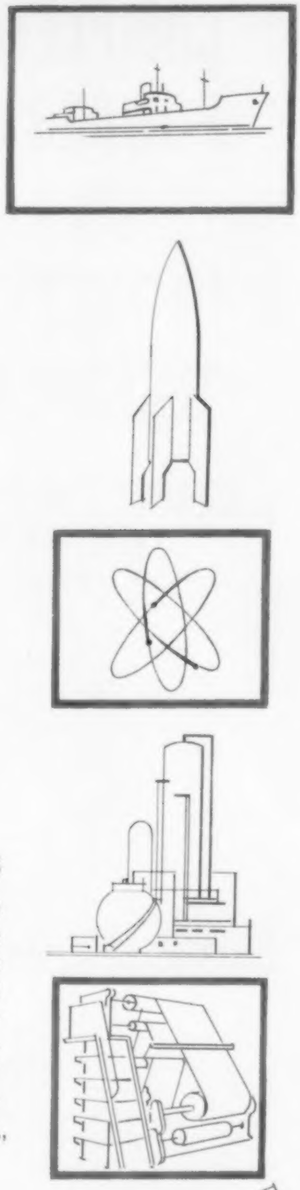

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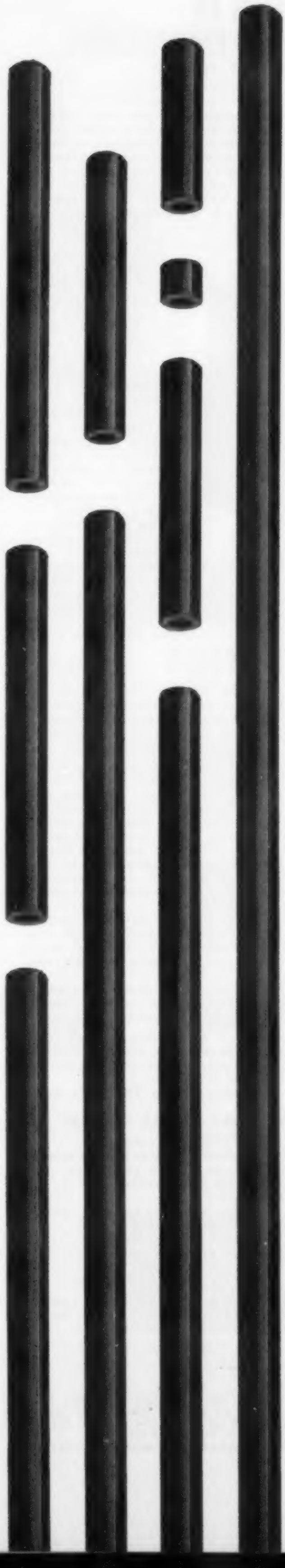

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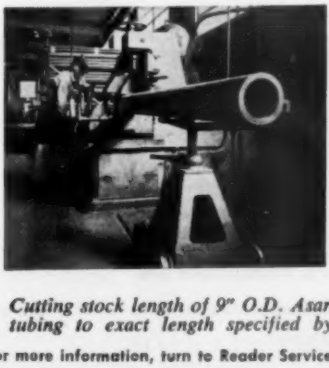

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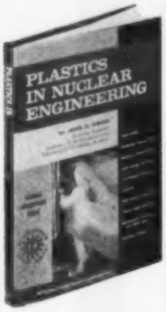

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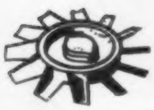

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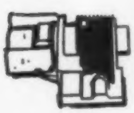

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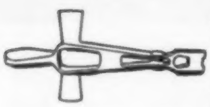

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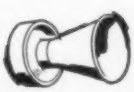

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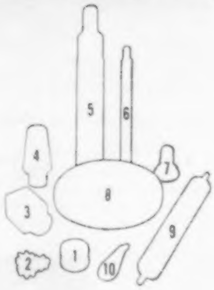

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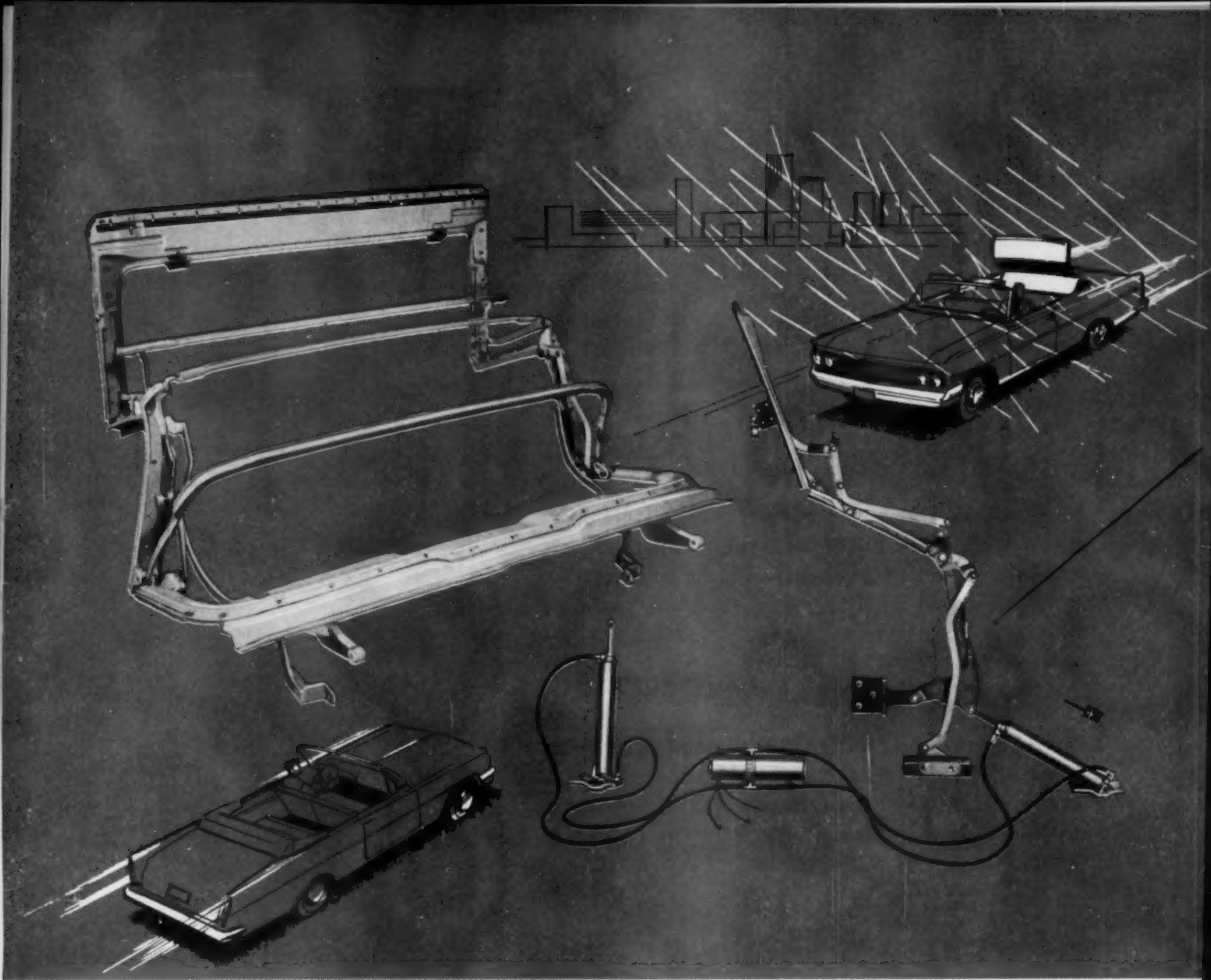

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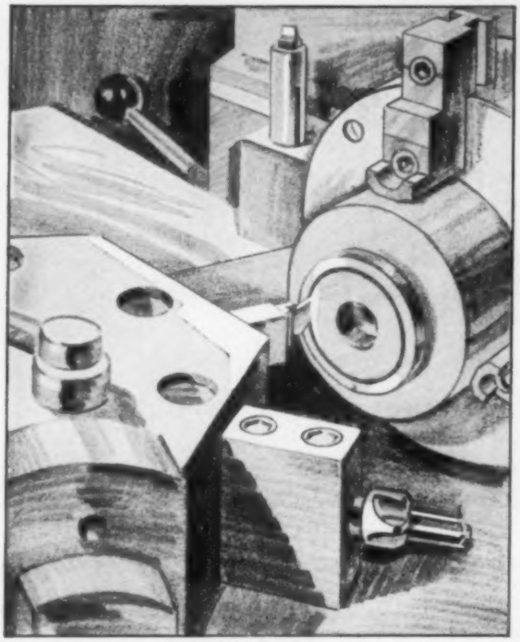

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Elongation	7-10 (most ductile)	2-9	1-3
Brinell Hardness	82-91 (hardest)	50-80	60-62
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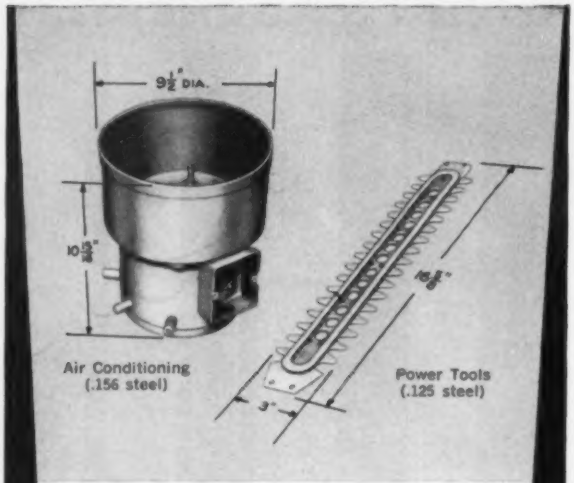

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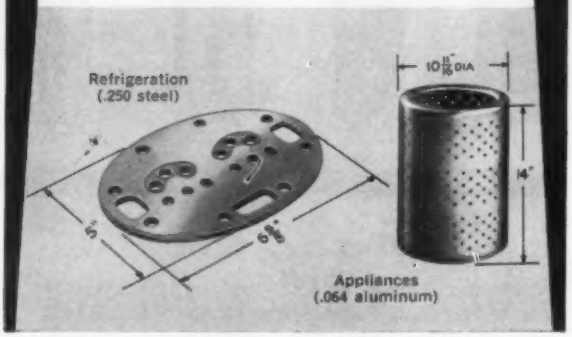

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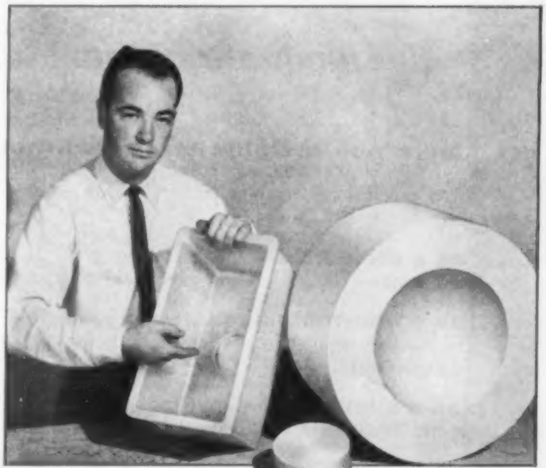

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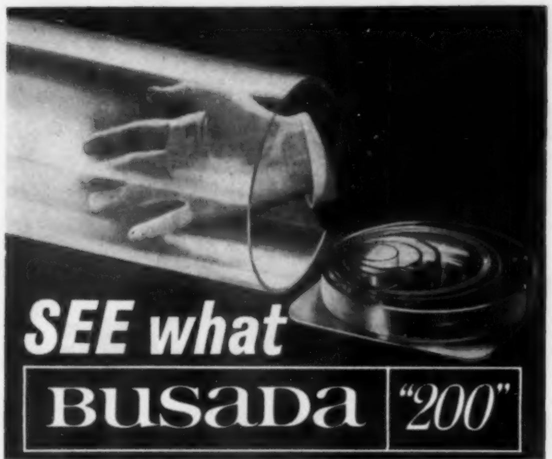

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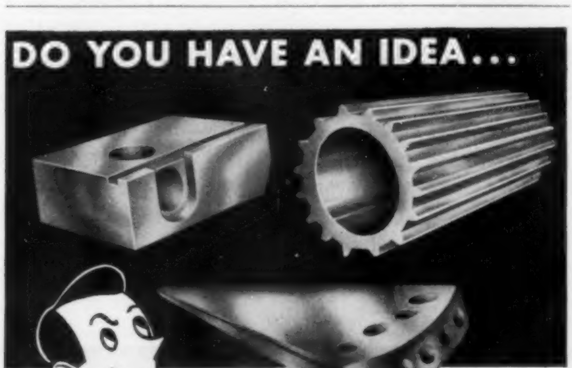

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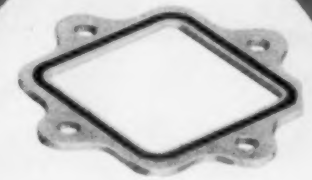

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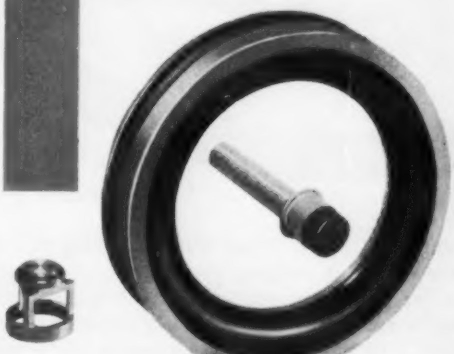

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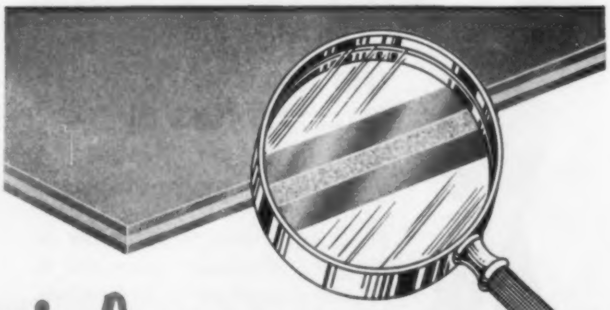

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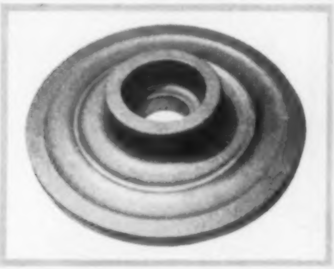

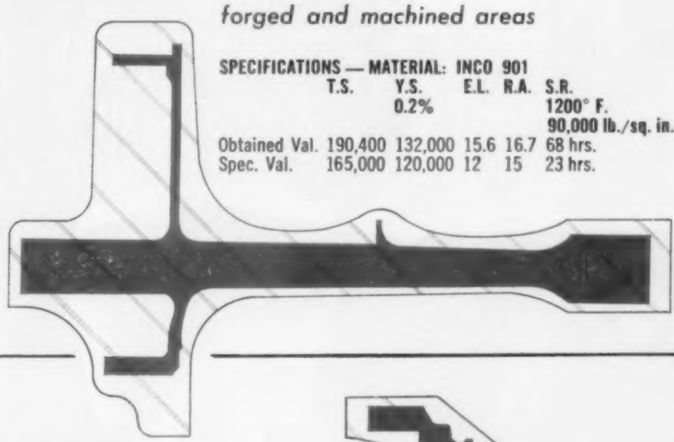

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Spec. Val.	165,000	120,000	12	15	23 hrs.

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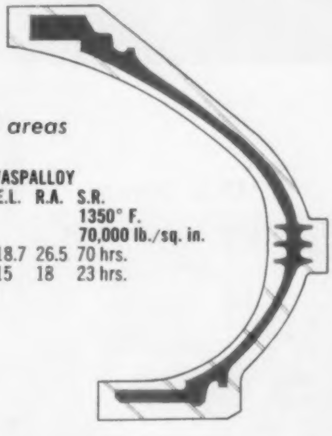

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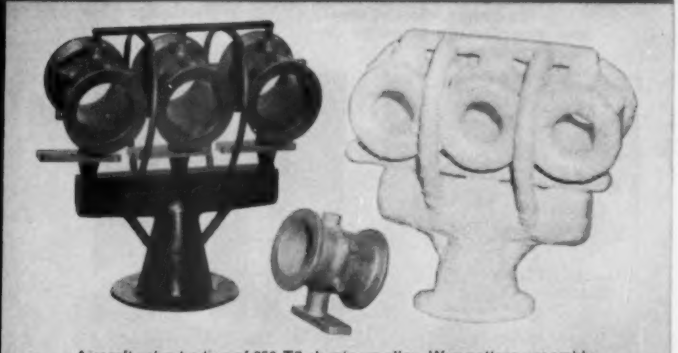

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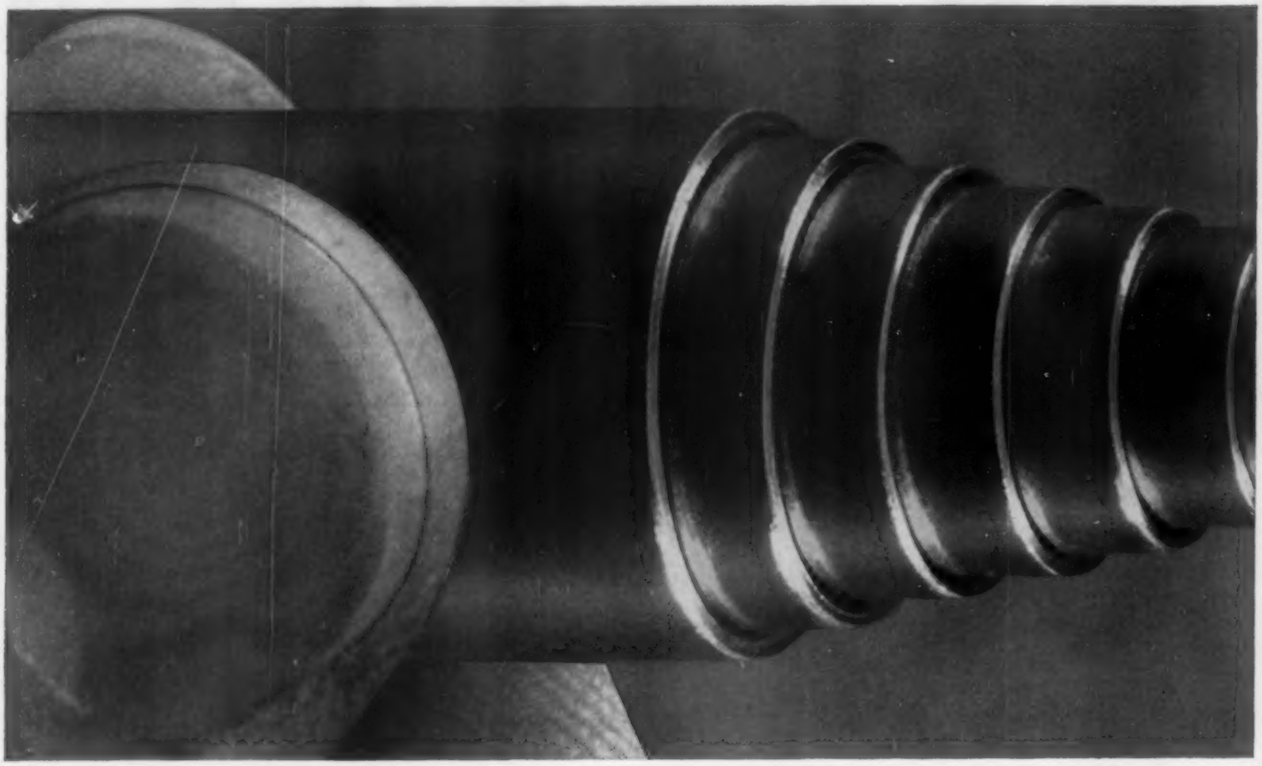


New material ideas from Superior to simplify tubing selection for your latest designs

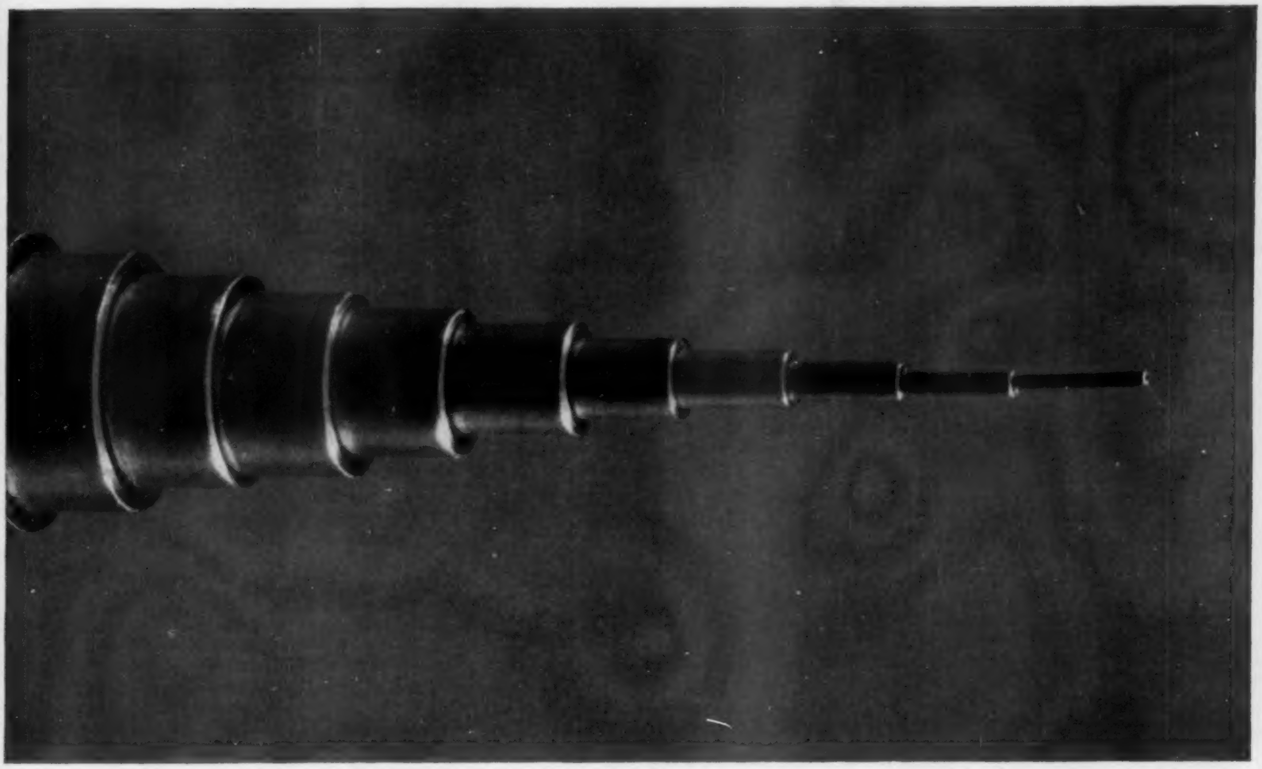
Superior's broad range of analyses (over 120) and sizes (.010 to ⅝ in. OD), including the new materials and the groups briefly described on these pages, offers you the near certainty of finding the small-diameter tubing just right for your specific application. We can produce close tolerance tubing from these analyses in any shape, to any practical mechanical property range, to the most exacting specifications. And we can offer many special services, including nondestructive testing to assure the quality of the finished tubing.

SUPER ALLOYS

In order to distinguish Super Alloys from ordinary heat-resistant alloys, we have defined them as metals which have a 1000-hr. creep rupture strength at 1200°F at 25,000 psi minimum stress in combination with resistance to progressive scaling (oxidation) and other types of corrosion. Short-time tensile properties at elevated temperature and creep rupture data on tubing made from AISI Type 316, Hastelloy X,[3] Hastelloy C,[3] Haynes 25,[3] Inconel 702,[2] A-286,[1] Inconel X[2] and Waspaloy are given in Bulletin 71.

REACTIVE METALS

Missile and nuclear reactor developments have helped guide Superior's program in producing tubing from the reactive metals. Titanium A-40, titanium alloy (3% aluminum, 2½%



vanadium), zirconium, Zircaloy 2,[4] Zircaloy 4,[4] columbium, 1% zirconium-columbium alloy, tentalum and vanadium are commercially available. Experimental production orders of tungsten-tantalum alloys, pure molybdenum, and molybdenum alloyed with titanium, aluminum and zirconium can be supplied. Write for detailed information.

PRECIPITATION HARDENING STAINLESS STEELS

Applications requiring severe fabrication in the annealed condition and subsequent heat treatment to obtain satisfactory spring properties can best be handled by analyses such as 15-7 MO,[5] AM-350,[1] and A-286. These also offer better corrosion resistance than carbon and alloy steel grades. Write for Stainless Steel Catalog 22.

COMPOSITES

Many different types of composites involving small-diameter tubing can be produced to meet specific mechanical, electrical and corrosion-resistance requirements. We can combine tubing of different analyses, make it of several plies of the same analysis, and draw it over materials supplied by customers. Typical examples of composites produced for our customers include seamless A Nickel over Type 321, Haynes 25 over 1% zirconium-columbium alloy, glass-sealing alloys over copper wire, carbon steel over asbestos-insulated constantan wire. Write for detailed information.

STANDARDS

No matter what your small-diameter tubing requirements are, Superior can satisfy them. In addition to Super Alloys, reactive metals, precipitation hardening stainless steels, and composites, we offer a complete line of carbon and alloy steels, stainless steels, nickel and nickel alloys, and glass-sealing alloys in tubing form. Sizes in all analyses range from .010 through ⅝ in. OD. Certain analyses in light walls up to 2½ in. OD. Bulletin 41 describes the standard types. Superior Tube Company, 2006 Germantown Ave., Norristown, Pa.

Registered trademarks:

[1]Allegheny Ludlum Steel Corp.
[2]International Nickel Co.
[3]Haynes Stellite Co.
[4]Westinghouse Electric Corp.
[5]Armco Steel Corp.
[6]Universal Cyclops Steel Corp.

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properties, and uses of prealloyed stainless steel and high alloy powders. **245**

Investment Castings. Howe Sound Co., Misco Precision Castings Co. Div., 16 pp, illus. Advantages, characteristics, and typical uses of precision investment castings. **246**

Plastics Properties. A. L. Hyde Co. Chart gives mechanical and electrical properties, and test methods, for polycarbonate, acetal, nylon, and acrylic plastics. **247**

Aluminum Extrusions. Jarl Extrusions, Inc. Information on producing and anodizing aluminum extrusions. **273**

Pressed Parts. Lenape Hydraulic Pressing & Forging Co. Catalog shows numerous parts press formed by this company. **248**

Reinforced Plastics Moldings. G. B. Lewis Co., Plexton Dept., 24 pp, illus. Information on properties, tests, design, tools and dies, molding methods, fabrication and assembly, finishing and painting, and other data on reinforced plastics molding. **249**

Specially Shaped Wire. Little Falls Alloys, Inc., 4 pp, illus. Properties, specifications and available alloys in which specially shaped round, flat, square and rectangular wire is available. **250**

Malleable Iron Castings. Malleable Castings Council, 8 pp, illus. Design considerations, machinability, and impact and corrosion resistance of standard and pearlitic, malleable iron castings. **251**

Meehanite Castings. Meehanite Metal Corp., 60 pp, illus., No. 49. Advantages, characteristics, properties, specifications, typical applications, heat treatments, and other information on the Meehanite casting process and each type of metal available. **252**

Zirconium Metal Parts. Zirconium Metals Corp. of America, Div. of National Lead Co., 5 pp. Composition, corrosion resistance, mechanical properties, machinability and uses of reactor and commercial grades of zirconium metal parts. **253**

Impact Extrusions. Mueller Brass Co. Mechanical properties and dimensional tolerances of round, rectangular and square impact extrusions. **274**

Wire Cloth. Newark Wire Cloth Co., 4 pp, illus. How to select, use and check various grades and types of wire cloth. **254**

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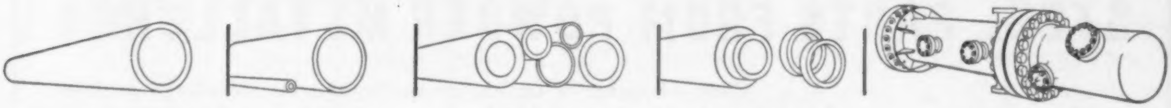
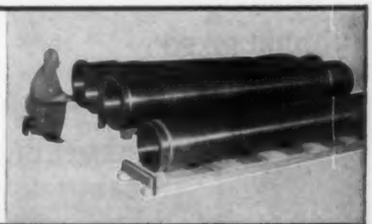
Sandusky Centrifugal Castings are available in stainless, carbon and low-alloy steels, full range of copper-base and nickel-base alloys



up to 33 feet long (depending on diameter or wall thickness) — from 7 to 54 inches in outside diameter — light or heavy walled components — annular parts sectioned from these cylinders — or fabrications which incorporate straight cylindrical sections

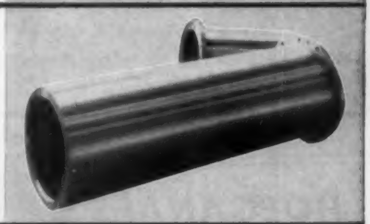
IN GENERAL INDUSTRY

Rolls, bushings, bearings, sleeves, liners and other cylindrical parts made from Sandusky Centrifugal Castings are widely used in industrial processing and fabrication. Our ability to produce cylinders of great size without welding has special significance to manufacturers and users of heavy equipment.



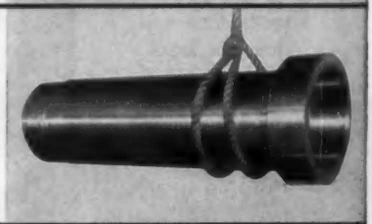
IN MARINE APPLICATIONS

Our centrifugal castings have been meeting the special requirements of the U. S. Navy and modern merchant marine fleets for many years. They are serving as propeller shaft sleeves, stern tubes, bushings, rudder stock sleeves, hawse pipes, dredge spuds and other marine components.



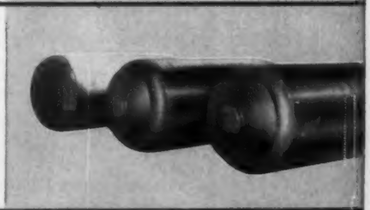
IN NUCLEAR SYSTEMS

Sandusky Centrifugal Castings are finding increasing use in the nuclear field as pressure vessels, pressure piping, canned motor pump stator shells, fuel handling tools and other components. Cylinders we produce from stainless and carbon steels, bronzes and Monels are used in the U. S. Navy's nuclear submarines.



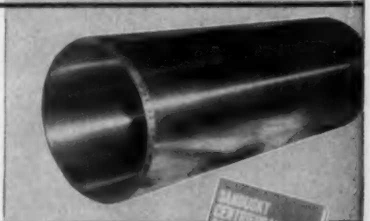
IN UNFIRED PRESSURE VESSELS

Sandusky Centrifugal Castings meet the requirements and approval of ASME Codes regulating the construction of unfired pressure vessels. Among these are hydraulic jack cylinders, pressurizers, test loop components, heat exchanger shells, and dam gate hoist cylinders—many finish machined in our shops.



IN REFINERY, PETROCHEMICAL APPLICATIONS

Case 32 Interpretations of 1955 Code For Pressure Piping published in MECHANICAL ENGINEERING, April, 1960, approves the use of centrifugally cast pipe for piping systems, under Section 3 of ASA B31. Ammonia synthesis converter cartridges, chemical reactor vessels, and heat exchanger bodies are other typical applications of Sandusky Centrifugal Castings.



For complete information on Sandusky Centrifugal Castings—and practical, economical answers to your cylindrical needs—write for new Product Book No. 500. Address SANDUSKY FOUNDRY & MACHINE COMPANY, SANDUSKY, OHIO.

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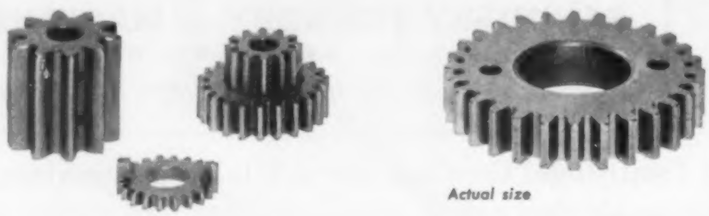

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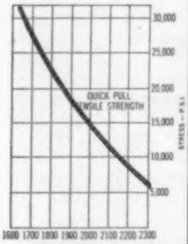
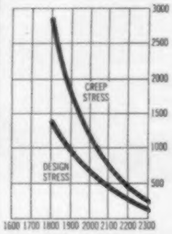
Because HOM can extend the useable range of the so-called high alloy casting from 1800°F to 2300°F, and because it is relatively new, we suggest that you outline your requirements to our metallurgical engineers and then work out its possible applications.

*DURALOY "HOM" covered by U.S. Letters Patent

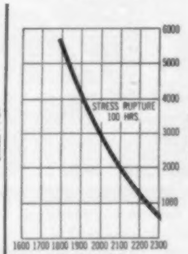
Curves Showing High Temperature Short-Time Tensile Strength of DURALOY-HOM



Curves Showing Creep Stress For Creep Rate of 1% in 10,000 Hours And Recommended Design Stress For DURALOY-HOM



Curve Showing Stress To Rupture at 100 Hours for DURALOY-HOM



Physical Properties of High Alloy Castings • CORROSION RESISTING

ALLOYED PRINCIPALLY TO MEET CORROSIVE CONDITIONS

CHARACTERISTICS	UNIT OF MEASURE	CA 15	CA 40	CB 30	CC 50	CF 8	CF 20	CH 20	CK 20
Weight	lbs./cu. in.	0.275	0.275	0.272	0.272	0.280	0.280	0.280	0.280
Shrinkage Allowance for Pattern Construction	in/ft	3/16	3/16	3/16	3/16	9/32	9/32	9/32	9/32
Electrical Resistance at 70°F.	ohms/ cir. mil. ft.	468	457	457	462	457	468	504	540
Specific Heat	btu/lb/ °F. at room temp.	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.12
Thermal Conductivity	btu/hr/ sq. ft./ ft./°F.	—	—	—	—	—	—	—	—
70°–212°F.		14.5	14.5	12.8	12.6	9.2	9.3	8.2	8.2
70°–1000°		16.7	16.7	14.5	17.9	12.1	12.3	10.9	10.9
70°–1500°		—	—	—	—	—	—	—	11.9
70°–2000°		—	—	—	—	—	—	—	—
Physical Properties at Room Temperature									
Condition *		Ann.	Ann.	Ann.	AC	WQ	WQ	WQ	WQ
Tensile Strength	lbs./sq. in.	95,000	110,000	75,000	70,000	78,000	80,000	88,000	76,000
Yield Strength	lbs./sq. in.	65,000	67,000	50,000	65,000	35,000	35,000	50,000	38,000
Elongation	% in 2"	20	18	10	2	55	55	30	30
Modulus of Elasticity	lbs./sq. in. x 10⁶	29	29	29	29	28	28	28	29
Brinell Hardness		180	210	210	210	180	196	180	180
Thermal Expansion	in./in/°F. x 10⁻⁶								
70°–212°F.		5.5	5.5	5.7	5.7	9.0	9.6	8.3	8.0
70°–1000°		6.4	6.4	6.5	6.5	10.0	10.4	9.6	9.2
70°–1200°		6.6	6.6	6.6	6.6	10.2	—	—	9.4
70°–1400°		6.8	6.7	6.8	6.8	10.4	—	—	9.6
70°–1600°		—	—	—	—	—	—	—	9.7
70°–1800°		—	—	—	—	—	—	—	10.0
70°–2000°		—	—	—	—	—	—	—	10.1

*Ann. = Annealed Ac = Air cooled WQ = Water Cooled

Physical Properties of High Alloy Castings • HEAT RESISTING

ALLOYED PRINCIPALLY TO MEET HIGH TEMPERATURES

CHARACTERISTICS	UNIT OF MEASURE	HA	HC	HD	HE	HF	HH	HK	HL	HT	HU	HW HX
Weight	lbs/cu. in.	0.275	0.274	0.274	0.276	0.280	0.279	0.280	0.279	0.286	0.286	0.300
Shrinkage Allowance for Pattern Construction	in./Ft.	3/16	3/16	9/32	9/32	9/32	9/32	9/32	9/32	9/32	9/32	9/32
Electrical Resistance at 70°F.	ohms/ cir. mil. ft.	457	462	487	510	480	504	540	564	600	631	—
Specific Heat	btu./ lb./°F. at room temp.	0.11	0.12	0.12	0.14	0.12	0.12	0.12	0.12	0.11	0.11	—
Thermal Conductivity	btu./hr./ sq. ft./ ft./°F.											
70°–212°F.		—	12.6	12.6	—	9.0	8.2	8.2	8.2	7.7	—	—
70°–1000°		—	17.9	17.9	—	13.4	10.9	10.9	10.9	11.4	8.9	—
70°–1500°		—	20.3	20.3	10.0	15.0	14.3	11.9	11.9	—	—	—
70°–2000°		—	24.2	24.2	—	16.9	16.4	—	—	—	—	—
Physical Properties at Room Temperature												
Condition *		Ann.	AC	AC	AC	AC	AC	AC	AC	AC	AC	AC
Tensile Strength	lbs./sq. in.	95,000	70,000	65,000	85,000	80,000	85,000	75,000	85,000	70,000	70,000	68,000
Yield Strength	lbs./sq. in.	65,000	65,000	48,000	45,000	40,000	50,000	47,000	53,000	40,000	40,000	40,000
Elongation	% in 2"	18	2	10	10	25	15	17	19	10	10	8
Modulus of Elasticity	lbs./sq. in. x 10⁶	—	—	—	—	28	29	29	—	—	—	—
Brinell Hardness		180	210	190	200	190	195	187	190	180	170	175
Average Maximum Temperature at Which Alloy Can Normally be used without Excessive Oxidation	°F.	1,300	2,000	2,000	2,000	1,800	2,100	2,100	2,100	2,100	2,100	2,100
Strength at Elevated Temperature	creep stress 1% creep in 10,000 hrs.											
1000°F.		16,000	—	—	—	—	—	—	—	18,000	—	—
1100°		7,200	—	—	—	—	—	—	—	13,500	—	—
1200°		3,100	—	—	—	—	—	11,700	—	—	—	—
1300°		2,200	—	—	—	—	—	8,300	—	—	—	—
1400°		1,300	1,400	3,500	4,500	5,200	6,000	6,500	7,000	8,000	8,800	6,000
1500°		1,050	—	—	—	—	—	5,300	—	6,400	—	—
1600°		—	750	1,900	2,400	2,900	3,500	4,200	4,300	4,800	5,000	4,000
1700°		—	—	—	—	—	—	3,000	—	—	—	—
1800°		—	300	1,000	1,600	1,800	2,000	2,500	2,200	2,400	2,700	2,000
1900°		—	—	—	—	—	—	1,400	—	—	—	—
2000°		—	—	—	—	—	1,000	1,100	—	—	—	—
Thermal Expansion	in./in/°F. x 10⁻⁶											
70°–212°F		5.5	5.9	—	—	—	—	8.0	—	—	—	—
70°–1000°		6.4	6.3	7.7	9.5	9.9	9.6	9.2	9.2	8.5	—	—
70°–1200°		—	6.3	—	9.9	10.1	9.8	9.4	—	8.9	8.9	8.9
70°–1400°		6.7	6.8	—	10.2	10.3	9.9	9.6	—	9.2	9.2	—
70°–1600°		—	7.0	8.6	10.5	10.4	10.0	9.7	9.7	9.3	9.3	9.1
70°–1800°		—	7.4	—	10.8	10.5	10.8	10.0	—	9.8	—	9.4
70°–2000°		—	7.7	9.2	—	10.9	—	10.1	10.1	9.8	9.7	9.7

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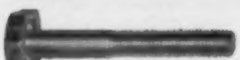

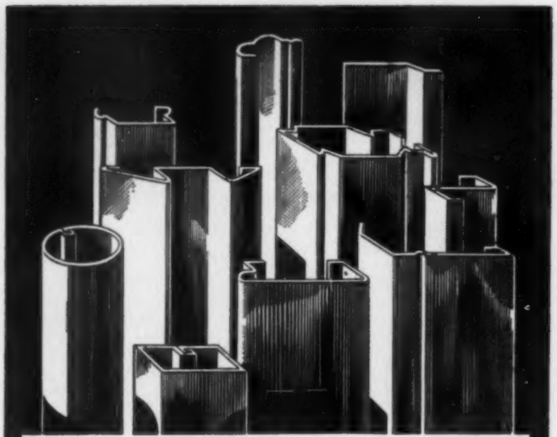

SUPPLIERS' LITERATURE

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Zinc Die Castings. New Jersey Zinc Co., Market Development Div., 62 pp, illus. Discusses the use of zinc die castings in appliances, hardware, industrial equipment, automobiles, toys and photographic equipment. **255**

Perforated Materials. Perforating Industries, Inc., 22 pp, illus., No. 60. General information on where and why perforated materials are used; materials which can be perforated, slit, and blanked; typical applications; and a series of illustrations indicating patterns, sizes, number of holes per inch, and other information on various perforated materials. **256**

Plastics-Impregnated Wood. Permali Inc., 6 pp, illus. Dimensional data, uses, and mechanical, physical and electrical properties of laminated thin wood veneers that are impregnated under vacuum with a special synthetic resin. **257**

Aluminum Extrusions. Precision Extrusions, Inc., 2 pp, illus., No. 17. Information on the use of extruded aluminum in a new air distribution system. **258**

Carbon and Graphite Parts. Pure Carbon Co., Inc., 12 pp, illus., No. 55. Catalog on carbon and graphite parts for mechanical applications. **259**

Metal Stampings. Reichert Float & Mfg. Co., 8 pp, illus. Shows facilities for special forming and deep drawing intricate, light and heavy metal stampings. **260**

Forgings. Rhode Island Tool Co., 26 pp, illus., No. 75. Dimensions, properties, prices and uses for drop and upset forgings, eye and special bolts, studs, cap screws, and nuts. **261**

Metal Stampings. Rockwell-Standard Corp., Stamping Div., 8 pp, illus. Describes facilities for producing large or small stampings and assemblies in any metal or alloy. **262**

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Centrifugal Castings. Sandusky Foundry & Machine Co., 16 pp., illus., No. 300. Describes and illustrates the use of centrifugal castings for unfired pressure vessels, radioactive systems and other critical applications. **264**

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Silicone Rubber Moldings. Stillman Rubber Co. Information on swell, low and high temperature characteristics, hardness, and adaptability to molding and extruding processes of a special silicone rubber formulation for seals and gaskets. **265**

Titanium Tubing. Superior Tube Co., 3 pp, illus., No. 27. Chemical compositions, physical and mechanical properties, and size limits for seamless titanium and titanium alloy tubing. Included is information on heat treating and welding. **266**

TFE Sheets, Rods. Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., 8 pp, illus. Properties, uses, fabrication and quality control of TFE sheets, rods, tubes, tapes and other standard shapes. **267**

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Corrosion Resistant Castings. Waukesha Foundry Co., Castings Div., 18 pp, illus. Information on services and facilities available for the production of corrosion resistant castings. Includes information on properties, uses, and characteristics of stainless steel and special alloy castings. Includes a chart which recommends specific casting alloys for specific service requirements. **268**

Mechanical Rubber Goods. Williams-Bowman Rubber Co., 6 pp, illus. Information on the services and facilities available for the production of mechanical rubber goods. **311**

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Glass Sealing Alloys. Driver-Harris Co., 4 pp, illus. General description, composition, properties and typical uses of several glass-to-metal sealing alloys. **279**

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Mechanical Fasteners. Grip Nut Co., 20 pp, illus., No. 161. General description, specifications, sizes, advantages, characteristics, physical and mechanical requirements, typical applications, and other information on lock nuts, clinch nuts, weld nuts, and special nuts. **285**

Silver Alloy Brazing. Handy & Harman, 4 pp, illus. Examples of the use of silver alloy brazing to join various components and products involving similar and dissimilar metals. **286**

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Self-Locking Nuts. Mac Lean-Fogg Nut Co., 8 pp, illus., No. 7-Ma. Properties, uses and dimensions of self-locking nuts. **290**

Adhesives, Coatings, Sealers. Minnesota Mining & Mfg. Co., Adhesives, Coatings & Sealers Div., 12 pp, No. A-ZBD-102-JR. Series of fold-out tables give uses, characteristics, and general properties of over 170 different adhesives, coatings and sealers. **291**

Mechanical Fasteners. National Machine Products Co., 8 pp, illus. Information on sizes, uses and advantages of a line of mechanical fasteners. **292**

Adhesives Selection, Use. Raybestos-Manhattan, Inc., Adhesives Dept., Bridgeport, Conn., 20 pp, illus., No. 701. Information on selection, bonding, testing, inspection, and use of a line of adhesives. Included is a comprehensive chart covering characteristics, solvents, uses, and bonding requirements of several dozen adhesives. Write on company letterhead directly to Raybestos.

Welding Titanium. Republic Steel Corp., 24 pp, illus., No. 3. Data on the latest approved methods of fabricating and welding titanium and titanium alloys. Covers forming, cutting, blanking, tooling, lubricants; and fusion, resistance flash butt, and pressure welding; and brazing. **293**

Adhesives. Rogers Corp., 3 pp, No. TSB-221. Information on bonding reinforced TFE to itself and to metals, including data on surface etching, adhesive types, metals, etc. **294**

Adhesives. Rubber Latex Co. of America. Series of technical bulletins give information on properties, applications, procedures, and how to select the best adhesive for a specific requirement. **295**

Screws. Russell, Burdsall & Ward Bolt & Nut Co., 8 pp, illus. Advantages and specifications of Spin-Lock screws available in hex, pan, truss or flat heads. **296**

Set Screws. Set Screw & Mfg. Co., 28 pp, illus. No. 21. Information on self-tapping and stainless steel set screws. **297**

Fasteners. Simmons Fastener Corp. 42 pp, illus., No. 1257. Sizes, installation data, characteristics and uses of plastics and metal fasteners. **298**

Self-Locking Blind Nut. Standard Pressed Steel Co., Industrial Fastener Div., 6 pp, illus., No. 2681-660-25C-SPS. Advantages, characteristics, typical uses, and specifications for a one-piece self-locking blind nut. **299**

Speed Nuts. Tinnerman Products, Inc., 18 pp, illus., No. 353. Seventeen case histories describe assembly saving achieved through the use of Speed Nut mechanical fasteners. **300**

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Pop Rivets. United Shoe Machinery Corp., "Pop" Rivet Div., 8 pp, illus. General description, advantages, method of selection, and other pertinent data on two basic types of Pop rivets. **303**

Epoxy Pellet Adhesives. Joseph Waldman & Sons, Epoxy Products Div., 4 pp, No. 6. Bond strength; thermal, electrical, and chemical characteristics; selection information; and typical applications of epoxy pellet adhesives. **305**

New Brazing Alloy. Wall Colmonoy Corp., Stainless Processing Div., 1 p, No. 2:1:12. Advantages, characteristics, composition, metallurgical and engineering properties and typical applications of a new brazing alloy. **306**

Nylon Screws. Weckesser Corp., 3 pp, illus. Installation data for black nylon screws and nuts. **307**

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JOINING AND FASTENING

JOINING AND FASTENING

Joinability of Materials[a]

Material ↓	Arc Welding	Oxyacetylene Welding	Resistance Welding	Brazing
Cast Iron	Common by shielded metal arc where ductile weld not required	Rec with cast iron rods; braze welding if no corr or thermal stress	Seldom; if used, flash welding preferred	Dfclt; easiest for quality-controlled and Ni-cont types
Carbon and Low Alloy Steels	Rec for low carbon and low alloy, common for medium, dfclt for high; all processes	Rec with rods of same comp for low carbon, low alloy; incr C makes more dfclt	Rec for low carbon and low alloy; flash and upset used as C incr dfclt	Rec for low, medium carbon; dfclt for high; seldom for heat treated alloy steels
Stainless Steel	Rec for 200 and 300 series, common for 400 series; all processes[b]	Common for thin gages, dfclt for thicker	Rec for 300 series; 400 series susceptible to hardening	Rec with silver brazing alloys[b]
Aluminum, Magnesium	Common by inert gas; Al slightly easier than Mg	Common for Al <1 in., Mg & M1 alloy; others dfclt	Common; Mg more dfclt, though spot welding used	Common for Al alloys and Mg alloy M1
Copper and its Alloys	Common by inert gas; electrolytic Cu joints not high str	Common for most; seldom for phosphor and aluminum bronzes	Common by upset or modified flash upset methods	Rec for Cu and high Cu brasses; ease with bronzes varies widely
Nickel and its Alloys	Rec for Ni, monel, Inconel; all processes	Common for Ni, monel, Inconel	Rec for most; Inconel X dfclt	Rec
Titanium	Common by inert gas	No	Common by spot and flash welding	Difficult
Lead, Zinc	Common for lead by inert gas; no for zinc	Common	Dfclt for zinc, but spot and seam used; no for lead	No
Thermoplastics	(Heated tool welding.) Rec for acrylic sheet, common for most TP sheet	(Hot gas welding.) Rec for polyethylene, PVC; common for other TP's	(Induction welding.) Common for polyethylene, acrylic; metal insert remains integral	No
Thermosets	No	No	No	No
Elastomers	No	No	No	No
Ceramics	No	Seldom	No	No
Glass	Seldom	(Blow torch.) Common	No	No
Wood	No	No	No	No
Leather	No	No	No	No
Fabric	No	No	No	No
Dissimilar Metals	Dfclt; used where melting points are within about 50 °F; galvanic action danger	Dfclt; used when melting points are within about 50° F; galvanic action danger	Dfclt; special procedures because of different thermal prop.; galvanic action danger	Ranges from dfclt to common depending on deg of dissimilarity
Metals to Nonmetallics	No	No	No	No
Dissimilar Nonmetallics	(Hot gas welding.) Dfclt; used on TP's of same basic type	(Hot gas welding.) Dfclt; used on TP's of same basic type	No	No
Dissimilar Thicknesses	Common	Common	Common	Rec

[a] Abbreviations used in the table: TP = Thermoplastic. TS = Thermosetting. Elast = Elastomeric. Rec = Recommended; easily accomplished with excellent results. Common = Commonly and widely used, though some care may be necessary. Dfclt = Difficult; special precautions, equipment, etc., necessary. Seldom = Can be done with more or less difficulty, but not common for one reason or another. No = Not used; impossible or highly specialized case if ever used.

[b] The 300 series requires post weld heat treatment if subjected to corrosive environments

	Soldering	Adhesive Bonding (TS, TP, Elast)	Adhesive Bonding (modified compounds)	Threaded Fastening	Riveting and Metal Stitching
	Seldom; graphite and high silicon content prevent bonding	Common with TS, seldom with TP	Common with epoxy 100% solids; dfclt with solvent-dispersed phenolic	Common; esp self-tapping, also integrally cast studs, hooks, etc.	Rec with large solid rivets in structural uses
	Dfclt for lower carbon; seldom for higher carbon	Common with TS, seldom with TP	Common with epoxy 100% solids in paste form	Rec with all types; most fasteners made of same mtls	Rec with solid rivets for high shear, medium ten str uses
	Common [illegible] series with high [illegible] solders; dfclt for 400 series	Common with TS, seldom with TP	Common with epoxy 100% solids in paste form	Rec with bolts and nuts, common with others	Common with solid stainless steel rivets for high shear str uses
	Seldom; special solders available	Rec with TS, common with others, but no alkaline adh	Rec with all types	Common with self-tapping screws, inserts, others	Common with small solid aluminum rivets, or semi-tubular where low stress
	Rec for copper, brass, bronze in that order	Common with TS, seldom with TP, but no natural rubber adh	Common with epoxy 100% solids as paste or film	Common with fasteners available in similar mtls	Common with small solid copper alloy rivets, seldom with semi-tubular
	Common with high tin solders or others rel non-corr	Common with TS, seldom with TP	Common with epoxy 100% solids as paste or film	Rec with fasteners available in similar mtls	Common with small solid nickel alloy rivets, seldom with semi-tubular
	Seldom	Seldom with TS, no TP	Common with epoxy 100% solids, heat and pressure-cured	Common; some Ti fasteners available	No
	Rec with low melting solders	Rec with TS, TP, Elast in that order	Rec with all types	Rec with self-tapping screws, inserts, special fasteners	Rec with semi-tubular or split rivets, seldom with solid
	No	Common with Elast for cryst types; solvent selection care nec to avoid crazing	Seldom; phenolic-Buna N most used	Seldom; inserts are used, also special fasteners	Rec with tubular rivets; stitching common (limited thk)
	No	Common with TS; solvent selection care nec to avoid crazing	Common with modified epoxies on TP–TS compounds	Common with self-tapping screws, elevator bolts, inserts	Rec with semi-tubular rivets
	No	Rec with phenolic, epoxy and neoprene adhesives	Common with epoxy-polysulfide, phenolic-elastomers	Seldom; inserts are used, also special fasteners	Rec with tubular or split rivets; stitching common
	No	Rec with epoxy, common with other TS adhesives exc ureas	Rec with vinyl-phenolics, modified epoxies, phenolic-elastomers	Common with nuts, washers and bolts, esp load-indicating types	Seldom; semi-tubular rivets used
	No	Rec with TS, common with Elast	Rec with vinyl-phenolics, phenolic-elastomers	Common with plastics fasteners, seldom with elevator bolts	Seldom; TP semi-tubular rivets used
	No	Rec; phenolic for soft plywood, melamine-urea for laminations, PVC for furniture	Rec with solvent-dispersed phenolic-elastomers, latex emulsions	Rec with wood and lag screws, self-tapping screws, inserts, dowels, etc.	Common. Semi-tubular rivets for hard woods, tubular rivets for soft
	No	Rec with Elast, common with TS	Rec with asphalt and latex emulsions, solvent dispersions	Seldom	Rec with tubular and split rivets, and stitching or stapling
	No	Rec with Elast, polyvinyl acetate and cellulosic adh	Rec with asphalt and latex emulsions	Seldom	Rec with split rivets, stitching
	Rec except where galvanic corr must be considered	Rec with TS exc solvent-dispersed types	Rec with epoxy 100% solids	Common but galvanic action may be a danger	Common although galvanic action is a danger
	No	Rec. TP for shear str; TS Elast for peel str	Rec with solvent-dispersed phenolic-elastomers	Common using self-tapping screws, inserts, special fasteners	Rec with self-tapping screws, inserts, stitching
	No	Rec; type varies with porosities being joined	Rec; type varies with porosities being joined	Seldom	Rec with lag screws, stitching, special fasteners
	Rec	Rec where load is not peel	Rec with all types	Rec, esp bolts	Rec, esp stitching

Brazing and Soldering Alloys

Classification

Unlike welding filler metals, these alloys melt at lower temperature than the metals being joined —brazing alloys above 800 F, soldering alloys below.

Brazing Alloys. Alloys are classified by chemical composition. The two most common groups are silver alloys and copper and copper alloys. All must melt and flow freely at a lower temperature than the metals being joined, adhere to the surfaces being joined, and not oxidize or volatize too freely.

Brazing fluxes. Choice of the proper brazing flux is extremely important. Fluxes minimize oxidation, dissolve oxides that may have formed, and promote free flowing of the filler metal. A great number of proprietary fluxes are available, each with specific recommendations for use. Most of them can be classified as high temperature (above 1500 F), general-purpose low-temperature, or special purpose.

Soldering alloys. The most widely used soft solders are those composed of tin and lead, with or without other minor alloying elements. Other types include lead-silver, silver-tin-lead, bismuth-tin-lead, indium-bearing and aluminum solders.

Soldering fluxes. The most important factor in producing a sound soldered joint is the proper choice and use of a flux. The many available fluxes can be classified in two groups—corrosive and noncorrosive.

Brazing and Soldering Methods

Similar methods of heating are used for brazing and soldering. However, the furnace and salt dip methods are seldom used for soldering, and the soldering iron is not used for brazing. The most common methods use:

Soldering iron. The "iron" has a copper tip which is generally heated electrically. It is used mostly for electrical connections.

Torch. Oxyacetylene, oxyhydrogen or other gas flame torches are widely used for repair work.

Induction heating. Parts are assembled in a fixture which positions them inside an induction coil. Advantageous for large quantities of small parts.

Electric block. Similar to resistance welding with lower current. Used for small electrical parts.

Salt dip. Brazing alloy is preloaded into the work and parts are dipped into molten salt bath. Advantageous for dissimilar thicknesses and aluminum.

Metal dip. Parts are dipped in bath of molten brazing or soldering alloy. Used for irregular shapes.

Furnace. Brazing alloy is preloaded into work (usually held in jigs) which is then heated to brazing temperature in a controlled atmosphere furnace. Economical for large volumes of work.

Design Factors

Comparisons. Though brazed joints are not as strong as welded, the lower temperatures required are advantageous in that the process is faster, is performed more economically, and results in less distortion. Soldered joints are not recommended where any stress will be applied.

Joint design. Three basic types of joints are used in brazing: butt, scarf and lap. Lap joints are preferred where maximum strength is preferred. Butt joints are not recommended for soldering.

SOLDERING FLUXES

Flux ↓	Characteristics	Uses
Rosin	Noncorrosive, nonconducting, nonhygroscopic	Electrical
Tallow	Very mildly corrosive	Lead, brass, clean copper
Olive Oil or Gallipoli Oil	Very mildly corrosive	Pewter, block tin
Stearic Acid	Mildly corrosive, almost nonconductive	Electrical, lead
Aniline Phosphate or Aniline Chloride	Mildly corrosive, almost nonconductive	Electrical
Lerulinic Acid in Alcohol	Mildly corrosive, almost nonconductive	Tin cans
Lactic Acid, Phthalic Acid and Phosphoric Acid Mixed with Tallow, Resin, etc.	Mildly corrosive, slightly conductive	Electrical
Zinc Chloride	Corrosive	Iron, steel, zinc, copper, brass, bronze; terne and lead plate
Zinc Chloride and Hydrochloric Acid	Corrosive	Stainless steel, nickel, monel
Zinc Chloride and Hydrofluoric Acid	Corrosive	Brasses and bronzes containing aluminum, silicon and manganese
Orthophosphoric Acid	Corrosive	High tensile manganese bronze
Numerous Proprietary Pastes Usually Containing Zinc Chloride	Corrosive	—
Zinc Chloride and Ammonium Chloride	Corrosive	Iron, zinc, copper, brass, bronze
Dilute Hydrochloric Acid	Corrosive	Dirty zinc
Fused Salts of Zinc Chloride and Ammonium Chloride	Corrosive	Dipping method

Definitions

Eutectic. An alloy which has a melting *point* and not a *range*.

Liquidus. The lowest temperature at which the alloy is completely liquid.

Melting range. The range from the liquidus to the solidus temperature.

Solidus. The temperature at which the alloy begins to melt.

TYPICAL SOFT SOLDERS

ASTM Type ↓	Nominal Composition	Solidus, F	Liquidus, F	Spec Grav	Ten Str, 1000 psi	Applications
TIN-LEAD ALLOYS						
70A, 70B	Sn 70, Pb 30, Sb 0.12–0.50	361	378	8.32	6.8	Soldering Zn-coated ferrous metals; coating metals
....	Sn 62, Pb 38	361	361	—	—	General purpose; eutectic alloy
60A, 60B	Sn 60, Pb 40, Sb 0.12–0.50	361	374	8.65	6.4	General purpose, esp where temp needs critical
50A, 50B	Sn 50, Pb 50, Sb 0.12–0.50	361	421	8.85	5.9	General purpose; most commonly used for iron, steel, Cu alloys, Zn. Domestic plumbing
45A, 45B	Sn 45, Pb 55, Sb 0.12–0.50	361	441	8.97	—	Auto radiator cores, roofing seams
40A, 40B	Sn 40, Pb 60, Sb 0.12–0.50	361	460	9.3	5.8	Wiping lead pipes, cable sheaths. Auto radiator cores, galvanized iron and Zn heating units
35A, 35B	Sn 35, Pb 65, Sb 0.25–0.50	361	477	9.5	—	General purpose; wiping solder
30A, 30B	Sn 30, Pb 70, Sb 0.25–0.50	361	491	9.7	5.6	Machine, torch, dip, wiping methods
25A, 25B	Sn 25, Pb 75, Sb 0.25–0.50	361	511	10.00	—	Machine, torch methods
20B	Sn 20, Pb 80, Sb 0.5	361	531	10.20	5.3	Joining metal parts <¼ in. thk; filling dents or seams in auto bodies; coating metals
15B	Sn 15, Pb 85, Sb 0.50	361	550	10.50	—	Joining, coating; tinning auto bodies
10B	Sn 10, Pb 90, Sb 0.50	361	570	10.80	—	Joining, coating
5A, 5B	Sn 5, Pb 95, Sb 0.12–0.50	518	594	11.30	3.4	Joining and coating, esp at high temp to 250 F
TIN-LEAD-ANTIMONY ALLOYS[a]						
....	Sn 94, Pb 0.2, Sb 4–6	450	464	—	—	General purpose
40C	Sn 40, Pb 58, Sb 1.8–2.4	365	448	9.23	—	Same as 50A, 50B
35C	Sn 35, Pb 63.2, Sb 1.6–2.0	365	470	9.44	—	General purpose; wiping
30C	Sn 30, Pb 68.4, Sb 1.4–1.8	364	482	9.65	—	Torch, machine methods
25C	Sn 25, Pb 73.7, Sb 1.1–1.5	364	504	9.96	—	Same as above
20C	Sn 20, Pb 79, Sb 0.8–1.2	363	517	10.17	—	Machine soldering and coating; tipping
TIN-LEAD-INDIUM ALLOYS						
....	Sn 37.5, Pb 37.5, In 25.0	274	358	—	—	Where res to strong alk soln needed (high cost)
SILVER-LEAD AND SILVER-CADMIUM ALLOYS						
2.5 S	Sn 0, Pb 97.5, Sb 0.40, Ag 2.3–2.7	579	579	11.35	5.0	Cu, brass and similar metals with torch heating. Suitable for high temp but not for humid environ.
1.5S	Sn 1, Pb 97.5, Sb 0.40, Ag 1.3–1.7	588	588	11.28	—	Cu, brass and similar metals with torch heating. Sealing tin cans. High temp use
....	Ag 5, Cd 95	640	750	—	—	High temp use
CADMIUM-ZINC AND LEAD-CADMIUM-ZINC ALLOYS						
....	Pb 90, Cd 8, Zn 2	410	530	—	—	Zn and galvanized parts
....	Cd 82.5, Zn 17.5	508	508	—	—	Zn-base die castings; high temp
LOW MELTING ALLOYS (BISMUTH-CONTAINING)						
....	Bi 56, Pb 22, Sn 22	203	220	—	—	Special uses where low mp needed in soldering or svc
....	Bi 67, Pb 16, Sn 17	203	300	—	—	Same as above
....	Bi 40, Sn 60	281	338	—	—	Same as above
....	Bi 42.5, Pb 32.7, Sn 11.3, Cd 8.5	158	194	—	—	Same as above
....	Bi 58, Sn 42	281	281	—	—	Same as above
ALLOYS FOR SOLDERING ALUMINUM						
....	Sn 55–70, Zn 30–45	630	—	—	—	Range of special alloys for Al; also used on Mg
....	Sn 75, Zn 25	401	500	—	—	Soldering capacitors to Al sheets
ALLOYS FOR SOLDERING MAGNESIUM						
....	Sn 60, Zn 40	630	—	—	—	Magnesium
....	Cd 60, Zn 30, Sn 10	315	—	—	—	General purpose
....	Cd 90, Zn 10	500	—	—	—	Magnesium

[a] Not recommended for use on galvanized iron, cadmium or zinc parts.

continued on next page

Brazing and Soldering Alloys

BRAZING FILLER METALS

AWS-ASTM Class ↓	Major Composition %	Available Forms	Solidus, F	Liquidus, F	Special Factors
ALUMINUM-SILICON					
BAlSi-1	Si 4.0–6.0, Al bal	Strip, wire, rod	1070	1165	—
BAlSi-2	Si 6.8–8.2, Al bal	Coated sheet	1070	1135	Only as coating on 3003, 5951
BAlSi-3	Si 9.3–10.7, Cu 3.3–4.7, Al bal	Strip, wire, rod	970	1085	—
BAlSi-4	Si 11.0–13.0, Al bal	Strip, wire, powder	1070	1080	Highly corr res
COPPER-PHOSPHORUS					
BCuP-1	P 4.75–5.25, Cu bal	Strip, wire	1305	1650	More ductile than others; less fluid
BCuP-2	P 6.75–7.50, Cu bal	Rod	1305	1485	Very fluid
BCuP-3	P 6.00–6.50, Ag 4.75–5.25, Cu bal	Wire, rod, powder	1195	1500	Very fluid
BCuP-4	P 6.75–7.80, Ag 5.75–6.25, Cu bal	Rod, powder	1185	1380	—
BCuP-5	P 4.75–5.25, Ag 14.50–15.50, Cu bal	Strip, wire, rod, powder	1185	1500	Suitable where close fits cannot be held
SILVER					
BAg-1	Ag 44–46, Cu 14–16, Zn 14–18, Cd 23–25	↑	1125	1145	Free flowing, narrow melting range
BAg-2	Ag 34–36, Cu 25–27, Zn 19–23, Cd 17–19		1125	1295	Free flowing, broader melting range than above
BAg-3	Ag 49–51, Cu 14.5–16.5, Zn 13.5–17.5, Cd 15–17, Ni 2.5–3.5		1195	1270	Good wetting action on carbide; wide melting range; good corr res
BAg-4	Ag 39–41, Cu 29–31, Zn 26–30, Ni 1.5–2.5		1240	1435	Same as above, but freer flowing
BAg-5	Ag 44–46, Cu 29–31, Zn 23–27	Strip, wire, rod, powder	1250	1370	Wets, flows well; malleable, ductile
BAg-6	Ag 49–51, Cu 33–35, Zn 14–18		1270	1425	Same as above; low elec res, high ductility
BAg-7	Ag 55–57, Cu 21–23, Zn 15–19, Sn 4.5–5.5		1145	1205	Less stress corr cracking on stainless, some Ni alloys
BAg-8	Ag 71–73, Cu 27–29		1435	1435	Free flowing except on ferrous metals
BAg-9	Ag 64–66, Cu 19–21, Zn 13–17		1280	1325	—
BAg-10	Ag 69–71, Cu 19–21, Zn 8–12		1335	1390	—
BAg-11	Ag 74–76, Cu 21–23, Zn 2.5–3.5	↓	1365	1450	—
COPPER-GOLD					
BCuAu-1	Au 37.25–37.75, Cu bal	Strip, wire	1775	1815	[e]
BCuAu-2	Au 79.75–80.25, Cu bal	Strip, wire	1620	1630	[e]
COPPER					
BCu	Cu 99.90 min	Strip, wire, rod	1980	1980	Free flowing
COPPER-ZINC					
BCuZn-1	Cu 58.0–62.0, Zn bal	Strip, wire, rod	1650	1660	Free flowing; mod str
BCuZn-2	Cu 57.0 min, Sn 1.0, Zn bal	Strip, wire, rod	1630	1650	Free flowing; higher str than above
BCuZn-3	Cu 56.0 min, Sn 1.10, Mn 1.0, Ni 1.0, Zn bal	Strip, wire, rod	1590	1630	Used for capillary brazing
BCuZn-4	Cu 50.0–55.0, Zn bal	Grain	1570	1595	Low mp; somewhat brittle
BCuZn-5	Cu 50.0–53.0, Sn 3.0–4.5, Zn bal	Grain	1585	1610	Used for capillary brazing
BCuZn-6	Cu 46.0–50.0, Ni 9.0–11.0, Zn bal	Strip, wire, rod	1690	1715	Generally used to make V fillet
BCuZn-7	Cu 46.0–48.0, Ni 10.0–11.0, Ag 0.30–1.0, Zn bal	Strip, wire, rod, powder	1685	1710	High mp; good color match
MAGNESIUM					
BMg	Al 8.3–9.7, Zn 1.7–2.3, Mg bal	Wire, rod	770	1110	Good corr res; high str, ductility
HEAT RESISTING MATERIALS					
BNiCr	Ni 65–75, Cr 13–20, B 2.75–4.75[b]	Strip, wire, powder	1850	1950	Retains prop. to 2000 F
BAgMn	Ag 84–86, Mn 14–16	Strip, wire, rod	1760	1780	Good str at 500–900 F

[a] Immersion in 10% sulfuric acid restores copper color.
[c] Lap and tee; strong, ductile joint; shear strength 20–30,000 psi.
[e] All ferrous and nonferrous metals except Al, Mg, Ti and other metals melting below 1500 F. BAg-9, 10, 11 are used together for step brazing.
[b] BCuP-1: particularly resistance, and some furnace brazing.
[d] BAg-7 particularly for furnace brazing.

Brazing Methods	Brazing Temp Range, F	Flux	Nature of Joint	Color of Braze	Uses
Furnace, dip	1150–1185		Lap. Clearance <0.010 in. for laps <¼ in. long; but >0.025 in. for longer laps	Gray	Wrought Al alloys: 1100, 3003, 3004, 5050, 6951, 6053, 6061, 6062, 6063. Cast Al alloys: A612, C612
Furnace	1120–1140			Gray	
Furnace, dip	1060–1185	Essential		Gray	
Torch, dip, furnace	1090–1185			Gray	
	1450–1700		Clearance: 0.002–0.005 in.[e]	Lt Gray[e]	Cu, Cu alloys; limited use for Ag W, Mo. Do not use on ferrous alloys containing more than 10% Ni. Not rec for sulfurous atm above room temp
	1350–1550	Self-fluxing on copper; flux rec on other metals	Clearance: 0.001–0.003 in.[e]	Lt Gray	
All methods[b]	1300–1550		Clearance: 0.002–0.005 in.[e]	Lt Gray	
	1300–1500		Clearance: 0.001–0.003 in.[e]	Lt Gray	
	1300–1500		Clearance: 0.003–0.005 in.[e]	Lt Gray	
	1145–1400			Lt Yellow	Unstabilized types of stainless[e]
	1295–1550			Lt yellow	Where tolerances cannot be as closely controlled[e]
	1270–1500			Whitish yellow	Joining carbide tool tips to tool shanks[e]
	1435–1650		Lap rec; butt sometimes used. Clearances 0.002–0.005 in. Fatigue str about that of metals being joined (to 27,000 psi). Tough, ductile, high impact str; ten str, 50–60,000 psi	Lt yellow	Carbide tip brazing[e]
All methods[d]	1370–1550	Required unless brazing is done in vacuum or inert atm		Lt yellow	Elec equip.; food and dairy equip. where Cd-containing alloys might be prohibited[e]
	1425–1600			Lt yellow	Same as above
	1205–1400			Whitish	Food and dairy equip.[e]
	1435–1650			White	Assembling electronic tubes[e]
	1325–1550			Whitish	Particularly with sterling silver[e, f]
	1390–1600			Whitish	Same as above
	1450–1650			Whitish	Same as above
Induction, furnace, resistance	1815–2000	None[g]	—	Copperish	Special alloy for joining parts in electron tube assemblies
Same as above	1630–1850	None[g]	—	Copperish	Same as above
Furnace[h]	2000–2100	None[i]	Clearance: 0.000–0.002 in.[j]	Yellow	Ferrous metals; Ni and Cu-N alloys
Torch, furnace, induction	1670–1750			Yellow	Steels, Ni and Cu alloys
"	1670–1750			Yellow	Same as above
"	1670–1750	Required; borax-boric acid commonly used	Lap, butt; clearances 0.002–0.005 in. High str in shear and tension	Yellow	Same as above
"	1600–1700			Pale yellow	Steels, Ni alloys
"	1620–1700			Grayish yellow	Same as above
All methods	1720–1800			Gray	Same as above
All methods	1690–1800			Gray	Same as above
Torch, furnace, dip; sometimes others except resistance	1120–1160	Req; fluxes contain KCl, NaCl, some fluorides	Lap; clearances 0.004–0.010 in.	Gray	Mg alloy M1A
Furnace, generally using controlled dry H_2 atm	2000–2150	None in red. atm; otherwise necessary	Variable	Gray	Stainless steels, high Ni alloys; jet engines
Same as above	1780–2100	Same as above	Variable	Gray	Stainless steels, high Ni alloys; lower temp than BNiCr

[f] Variation in brazing temp permits step brazing.
[h] Using H_2 or dissociated ammonia atmosphere.
[j] Otherwise same nature as CuZn alloys.
[g] In reducing atmosphere or vacuum; otherwise borax-boric acid flux.
[i] Except on metals with oxide constituents.
[k] Total Fe + Si + C = 10% max.

Welding Electrodes and Rods

Classification

Welding rods and electrodes are generally grouped broadly according to the major metal (or metals) of which they are composed. Some are also grouped by the metals which they are used to weld. (These two classifications are often identical because it is usually desirable to weld base metals with a filler metal of similar composition.) A few groups of rods and electrodes are also defined by the welding method with which they are used.

Each broad group of rods and electrodes is further classified according to one or more of the following factors: chemical composition; coating, current and welding position; mechanical properties; appearance of the weld; intended end use. The key chart below is designed to indicate the method of classifying

EXPLANATION OF AWS-ASTM ROD AND ELECTRODE CLASSIFICATION NUMBERS
(And Key to the Charts in This Welding Section)

Electrode or Rod Group ↓	AWS-ASTM Spec	Sample Class No.[a]	Type of Specified Conditions Indicated by Class No.[b]	See Table No.
WELDING IRONS AND STEELS				
Mild Steel (coated and covered)	A233-58T	E6010	60—properties; 10—manner of use[c]	2a, 2b
Low Alloy Steel (covered)	A316-58T	E7010[e]	70—properties; 10—manner of use	2a, 2b
		E7010-A1[e]	70—properties; 10—modifies comp; A1—comp of weld	2a, 2c
Stainless Steel (covered)	A251-46T	E308ELC-15	308—comp of weld; ELC—modifies comp; 15—manner of use. Properties are also specified[d]	3
Stainless Steel (bare)[f]	A371-53T	ER308L	308—comp as mfd; L—modifies comp	3
For Welding Cast Iron[g]	A398-56T	RCuAl-A2	CuAl—comp as mfd; A2—modifies comp. Visual examination of weld is also specified[d]	4
For Gas Welding Irons and Steels	A251-46T	GA65	A65—properties	5
WELDING NONFERROUS METALS				
Copper and Copper Alloy	B225-53T (electrodes)	ECuAl-A2	CuAl—comp as mfd; A2—modifies comp. Properties are also specified[d]	6
	B259-52T (rods)	RCuAl-A2	CuAl—comp as mfd; A2—modifies comp	6
Nickel and Nickel Alloy	B295-54T (covered electrodes)	E3N10[h]	3—base metal; 1—welding method; 0—comp of core as mfd. Comp of weld, tensile strength are also specified[d]	7
	B304-56T (bare electrodes and rods)	ERN60	6—welding method; 0—comp as mfd	8
Aluminum and Aluminum Alloy	B184-43T (covered electrodes)	Al-2	2—comp of core as mfd	9
	B285-54T (bare electrodes and rods)	R-CN42A[i]	CN42—comp as mfd	9
Magnesium and Magnesium Alloy[f]	No specifications; alloys can be joined by gas welding and inert-gas shielded arc processes. In general, filler metal should have same composition as alloy being joined			
Lead and Zinc	No specifications; gas welding most commonly used. In general, filler metals should have same composition as alloy being joined			

[a] The first letter of the designation is either "E" for electrode or "R" for rod.
[b] The figures used are samples, e.g., the "10" for mild steels may be 11, 12, etc., each indicating a different manner of use. Properties = Mechanical properties of the deposited weld metal. (The figures approximate the minimum tensile strength in units of 1000 psi.) Manner of use = Type of current, polarity (if d.c.), welding position, type of covering.
[c] These figures also indicate modifications of specified properties and whether or not weld composition is specified.
[d] Specified, but not represented in the classification number.
[e] Must be classified one way or the other, not both.
[f] Used as both rods and bare electrodes. As rods—atomic hydrogen and inert-gas metal arc (nonconsumable electrode) welding. As bare electrodes—submerged arc and inert-gas metal-arc (consumable electrode) welding.
[g] Includes rods for oxyacetylene and carbon arc welding, covered electrodes for shielded metal arc welding. Types included here are: cast iron, copper-base, nickel-base and mild steel.
[h] The "N" designates "nickel."
[i] The "A" designates "aluminum."

1—TYPICAL PROPERTIES OF MILD STEEL ARC WELDED DEPOSITS

AWS—ASTM Class ↓	Ten Str, 1000 psi	Yld Point, 1000 psi	Elong (in 2 in.), %	Red. of Area, %	Impact Str, ft-lb*	Endur Limit, 1000 psi	Brinell Hardness
E4510, E4520	45	—	5	—	—	—	—
E6010	60–68	48–58	22–28	35–60	30–40, 15–25	28–32	140–160
E6011	60–70	48–61	22–30	35–60	30–40, 15–25	28–32	140–160
E6012	60–78	48–65	17–22	20–40	20–30, 5–15	—	150–170
E6013	60–78	48–65	17–22	25–50	25–35, 5–20	—	150–170
E6020, E6030	60–68	48–58	25–30	40–60	25–35, 15–25	30–34	150–170
E6027	60–68	48–55	25–30	40–60	25–35, 15–25	30–34	150–170
E6014	60–72	48–60	17–25	30–50	25–35, 15–25	—	—
E7014	70–85	58–77	17–25	30–50	25–35, 15–25	—	—
E6015, 6016	60–72	48–60	22–35	55–75	35–50, 25–40	—	140–160
E7015, 7016	70–76	58–62	22–35	55–75	35–50, 25–40	—	—
E6018	60–72	48–60	22–30	55–75	35–50, 25–40	—	—
E7018	70–85	58–70	22–30	55–75	35–50, 25–40	—	—
E6024	60–72	48–60	17–22	20–40	25–35, 10–20	—	150–170
E7024	70–85	58–75	17–22	20–40	25–35, 10–20	—	150–170
E6028	60–72	48–60	22–30	55–75	35–50, 25–40	—	—
E7028	70–85	58–74	22–30	55–75	35–50, 25–40	—	—

* Charpy keyhole. First value is at 70 F, second at −40 F.

each group according to American Welding Society specifications.

In some cases there is a choice offered by the specification; the manufacturer may be allowed to select one of several classification methods, or may be allowed to list an electrode by more than one classification.

The numbered charts on this and the following six pages classify the rods and electrodes within each group by the applicable method and also give other information, such as method of use, typical properties and some common applications.

Welding Processes

Arc welding. A group of processes wherein coalescence is produced by heating with an electric arc. The metal to be welded is one pole of an electric circuit and the electrode is the other pole. A suitable gap forms a heat generating arc. (The metal participates in the production of heat but is not the sole source.) Carbon or metal electrodes may be used. If covered metal electrodes are used the process is referred to as *shielded*. There are other methods of shielding, such as using an inert gas (helium or argon), or a blanket of granular, fusible material on the work (referred to as *submerged arc welding*).

Braze welding. Uses a brazing torch but is classified technically as a welding process because the filler metal is distributed by gravity and not, as in brazing, by capillary action.

Gas welding. A group of processes wherein coalescence is produced by heating with a gas flame, most commonly obtained by the combustion of acetylene with oxygen (*oxyacetylene welding*).

Resistance welding. A group of processes wherein coalescence is produced by the heat generated from resistance to flow of electric current through the work, and by pressure. Heat is generated in two places: in the body of the work where only the resistivity of the material determines the amount of heat; and at contact surfaces where resistivity is affected by pressure, surface oxides and compounds, and surface roughness and cleanliness. No fluxes or filler metals are used. Various types of resistance welding processes are named according to the method of determining pressure points. Examples

Definitions

Filler metal. A broad term for the metal added in making a weld. It may or may not carry electric current.

Rod. Filler metal, in wire or rod form, which does not carry current. Rods are used in gas welding or in arc welding with a separate carbon or tungsten electrode.

Electrode. The current-carrying element. With three exceptions, it is also the filler metal. Carbon and tungsten electrodes are not filler metals. The third exception is the "resistance welding electrode," a term applied to the part of the resistance welding machine that transmits current (and usually pressure) to the work. A resistance welding electrode may be in the form of a wheel, bar, cylinder, clamp, etc.

Bare, lightly coated, covered. Terms which apply to filler metals (either rods or electrodes) used in arc welding. However, since rods are usually bare, the terms are generally reserved for filler metal electrodes. The purpose of a light coating is primarily to stabilize the arc. "Covered" wires have a relatively thick coating which protects the molten metal from the atmosphere, improves weld metal properties, and stabilizes the arc.

Welding Electrodes and Rods

2a—MILD AND LOW ALLOY STEEL COVERED ELECTRODES
(Classified by Current, Welding Position and Covering)

AWS-ASTM Class ↓	Current, Polarity	Welding Position[a]	Covering	Slag[b]	Deposition Rate	Arc Characteristics
Exx10[c]	D.c. reversed	F, V, OH, H	High cellulose sodium	Thin	Slow	Spray, deep penetration
E6011	A.c. or d.c. reversed	F, V, OH, H	High cellulose potassium	Thin	Slow	Spray, deep penetration
E6012	A.c. or d.c.	F, V, OH, H	High titania sodium	Dense	Medium	Globule, medium penetration
Exx13	A.c. or d.c. straight	F, V, OH, H	High titania potassium	Medium	Med fast	Globule, shallow penetration
Exx14	A.c. or d.c.	F, V, OH, H	Iron powder, titania	Medium	Med fast	Globule, medium penetration
Exx15	D.c. reversed	F, V, OH, H	Low hydrogen sodium	Heavy	Medium	Globule, medium penetration
Exx16	A.c. or d.c. reversed	F, V, OH, H	Low hydrogen potassium	Heavy	Medium	Globule, medium penetration
Exx18	A.c. or d.c. reversed	F, V, OH, H	Iron powder, low hydrogen	Heavy	Fast	Globule, shallow penetration
Exx20[c]	A.c. or d.c.	H fillets, F	High iron oxide	Heavy	Fast	Spray, medium penetration
E6024	A.c. or d.c. either polarity	H fillets, F	Iron powder, titania	Heavy	Fast	Spray, shallow penetration
E6027	A.c. or d.c.	H fillets, F	Iron powder, iron oxide	Heavy	Fast	Spray, medium penetration
Exx28	A.c. or d.c. reversed	H fillets, F	Iron powder, low hydrogen	Dense	Fast	Spray, deep penetration
E6030	A.c. or d.c. either polarity	F	High iron oxide	Dense	Fast	Spray, deep penetration

[a] F = flat, V = vertical, OH = overhead, H = horizontal. [b] All slag deposits are readily removable except E6012 which is rated "fair."
[c] When xx = 45, the only column in this table that applies is "Welding Position." Current and polarity of 4510 and 4520 are not specified, but generally d.c. straight polarity is used. These two electrodes are not covered but are either sulcoated or light coated.

2b—MILD AND LOW ALLOY STEEL COVERED ELECTRODES
(Classified by Minimum Mechanical Properties)[a,b]

AWS-ASTM Class ↓	Ten Str, 1000 psi	Yld Point, 1000 psi	Elong (in 2 in.), %
MILD ALLOY STEEL ELECTRODES			
4510, 4520	45	Not spec	5
6010, 6011	62	50	22
6012, 6013, 6014, 6024	67	55	17
6015, 6016, 6018, 6028	67	55	22
6020, 6027, 6030	62	50	25
LOW ALLOY STEEL ELECTRODES			
70xx	70	57	22[c]
80xx	80	67	19[d]
90xx	90	77	17[e]
100xx	100	87	16[f]
110xx	110	97	15
120xx	120	107	14

[a] Classification by mechanical properties is represented by the first two digits. For low alloy steel electrodes the digits are exactly the minimum tensile strength in units of 1000 psi. For mild alloy steel the digits are approximately the minimum tensile strength.
[b] Chemical composition of low alloy steel welds is an alternative classification (see 2c). Chemical composition of mild alloy steel welds is additionally specified for electrodes of the following classes: Exx14-15-16-18-24-28. For these classes the maximum percentage composition is: Mo 0.30, Cr 0.20, Mn 1.25, Ni 0.30, V 0.08 (in addition the sum total of these elements shall not exceed 1.50%) and Si 0.90.
[c] Elongation is 25% for 7020. [e] Elongation is 14% for 9013.
[d] Elongation is 16% for 8013. [f] Elongation is 13% for 10013.

2c—LOW ALLOY STEEL COVERED ELECTRODES
(Classified by Chemical Composition of Weld)[a]

↓ AWS-ASTM Class	Composition (max), %
CARBON-MOLYBDENUM STEEL	
A1	C 0.12, Mo 0.40–0.65
CHROMIUM-MOLYBDENUM STEEL	
B1	C 0.12, Cr 0.40–0.65, Mo 0.40–0.65
B2L	C 0.05, Cr 1.00–1.50, Mo 0.40–0.65
B2	C 0.12, Cr 1.00–1.50, Mo 0.40–0.65
B3L	C 0.05, Cr 2.00–2.50, Mo 0.90–1.20
B3	C 0.12, Cr 2.00–2.50, Mo 0.90–1.20
B4L	C 0.05, Cr 1.75–2.25, Mo 0.40–0.65
NICKEL STEEL	
C1	C 0.12, Ni 2.00–2.75
C2	C 0.12, Ni 3.00–3.75
C3	C 0.12, Ni 0.80–1.10
MANGANESE-MOLYBDENUM STEEL	
D1	C 0.12, Mo 0.25–0.45, Mn 1.25–1.75
D2	C 0.15, Mo 0.25–0.45, Mn 1.65–2.00
OTHER (min %)[b]	
G	Mo 0.20, Cr 0.30, Mn 1.00, Si 0.80, Ni 0.50, V 0.10

[a] Classification of low alloy steel electrodes by chemical composition can be found in AWS-ASTM specification A316–[illegible]. Compositions are represented by a code following the sta[illegible]d classification, modified by the second two digits. This table gives only the percentages of the major elements.
[b] Deposit need have minimum of only one of elements listed.

are: *spot welding* (two welding tips pressing the work together in one spot at a time); and *projection welding* (welding dies are used and pressure points determined by projections designed as an integral part of the work). Other processes are named according to the speed of effecting contact and pressure and their timing with reference to the heating cycle (*flash* and *upset*).

3—STAINLESS STEEL RODS AND ELECTRODES

Covered Electrodes		Rods and Bare Electrodes		Applications	Min Mechanical Properties of Covered Electrode Deposits	
AWS-ASTM Class[a] ↓	Major Composition of Weld Metal, %[b]	AWS-ASTM Class[c] ↓	Major Composition As Manufactured, %[b]		Ten Str, 1000 psi	Elong (in 2 in.), %
E308......	C 0.08, Cr 18.0–21.0, Ni 9.0–11.0	ER308....	C 0.08, Cr 19.5–22.0, Ni 9.0–11.0	Weld base metal of similar composition	80	35
E308ELC ..	C 0.04, Cr 18.0–21.0, Ni 9.0–11.0	ER308L...	C 0.03, Cr 19.5–22.0, Ni 9.0–11.0	Low C reduces carbide precipitation, avoiding intergranular corrosion without need for stabilizers	75	35
E309......	C 0.15, Cr 22.0–25.0, Ni 12.0–14.0	ER309....	C 0.12, Cr 23.0–25.0, Ni 12.0–14.0	Weld similar alloys, wrought or cast. Weld 18-8 for severe corrosion conditions	80	35
309Cb.....	C 0.12, Cr 22.0–25.0, Ni 12.0–14.0, Cb+Ta 0.70–1.00	....	....	Primarily weld type 347 clad steel or dissimilar metals. Cb stabilizes against intergranular corrosion, provides high strength at high temperatures	80	30
E309Mo...	C 0.12, Cr 22.0–25.0, Ni 12.0–14.0, Mo 2.00–3.00	....	....	Primarily weld type 316 clad steels or dissimilar metals (similar to E309 with Mo added, C reduced)	80	35
E310......	C 0.20, Cr 25.0–28.0, Ni 20.0–22.0	ER310....	C 0.08–0.15, Cr 25.0,[d] Ni 20.0[d]	High strength, ductility useful in welding such hardenable steels as armor plate. Also weld clad steels	80	30
E310Cb....	C 0.12, Cr 25.0–28.0, Ni 20.0–22.0, Cb+Ta 0.70–1.00	....	....	Same uses as E309Cb	80	25
E310Mo...	C 0.12, Cr 25.0–28.0, Ni 20.0–22.0, Mo 2.00–3.00	....	....	Same uses as E309Mo	80	30
E312......	C 0.15, Cr 26.0–31.0, Ni 8.5–10.5	....	....	Primarily weld cast alloys of similar composition. A recent use: weld dissimilar metals when one is high in nickel	95	22
E316......	C 0.08, Cr 17.0–20.0, Ni 11.0–14.0, Mo 2.00–2.50	ER316....	C 0.08, Cr 18.0–20.0, Ni 12.0–14.0, Mo 2.0–2.5	Weld similar alloys containing 2 to 3% Mo. Molybdenum content provides creep resistance at high temperatures	80	30
E316ELC ..	C 0.04, Cr 17.0–20.0, Ni 11.0–14.0, Mo 2.00–2.50	ER316L...	C 0.03, Cr 18.0–20.0, Ni 12.0–14.0, Mo 2.0–2.5	Primarily weld extra low carbon, molybdenum-bearing austenitic alloys	75	30
E317......	C 0.08, Cr 18.0–21.0, Ni 12.0–14.0, Mo 3.00–4.00	ER317....	C 0.08, Cr 18.5–20.5, Ni 13.0–15.0, Mo 3.25–4.0	Weld similar alloys that must meet severe corrosion requirements involving sulfuric and sulfurous acids, salts	80	30
E318......	C 0.08, Cr 17.0–20.0, Ni 11.0–14.0, Mo 2.00–2.50, Cb+Ta 1.00[e]	....	....	Primarily weld metals of similar composition (identical to E316 with Cb added)	80	25
E330......	C 0.25, Cr 14.0–17.0, Ni 33.0 min	ER330....	C 0.15–0.25, Cr 15.0–17.0, Ni 34.0[d]	Repair defects in alloy castings; weld similar alloys. Nickel content gives heat and scale resistance above 1800 F	75	25
E347......	C 0.18, Cr 18.0–21.0, Ni 9.0–11.0, Cb+Ta 1.00[f]	ER347....	C 0.08, Cr 18.5–21.0, Ni 8.5–10.5, Cb+Ta 1.00[g]	Usually weld Cr-Ni alloys of similar composition stabilized with Cb or Ti	80	30
E410......	C 0.12, Cr 11.0–14.0, Ni 0.60	ER410....	C 0.07–0.12, Cr 12.0–14.0, Ni 0.6, Mo 0.6	Weld similar alloys; deposit overlays on carbon steels for corrosion, erosion and abrasion resistance. Air-hardening, it requires preheat and post-heat treatment to obtain ductility	70	20
....	....	ER420....	C 0.25–0.40, Cr 12.0–14.0, Ni 0.6	Similar to E410, but better resistance to corrosion, abrasion	—	—
E430......	C 0.10, Cr 15.0–18.0, Ni 0.60	ER430....	C 0.10, Cr 15.5–17.0, Ni 0.6	Similar to E410. Cr limit gives adequate corrosion resistance, yet retains ductility	70	20
E502......	C 0.10, Cr 4.0–6.0, Ni 0.40, Mo 0.45–0.65	ER502....	C 0.10, Cr 4.5–6.0, Ni 0.4, Mo 0.45–0.65	Weld similar metals, usually pipe or tubing	60	20

[a] The complete classification numbers are *Exxx-15* or *Exxx-16*. The *-15* suffix indicates a lime covering, *-16* a lime or titania covering. Polarity and welding position requirements are the same as those listed in chart 2 for Exx-15 and Exx-16.
[b] Maximum percentages unless otherwise specified. Carbon analysis required to nearest 0.01%.
[c] For consumable electrode welding, d.c. reversed polarity is preferred.
[d] Minimum. [e] Minimum is 6 x C. [f] Minimum is 8 x C. [g] Minimum is 10 x C.

continued on next page

Welding Electrodes and Rods

4—RODS AND ELECTRODES FOR WELDING CAST IRON

AWS-ASTM Class [a] ↓	Common Name[b]	Welding Method	Remarks	Uses
RCI	Cast iron	Oxyacetylene	Produces machinable deposit of same color, composition and structure as base metal	Fill in or build up new or worn gray iron castings. General fabrication, salvage, repair
ECI	Cast iron	Arc; a.c. or d.c. reversed polarity	Basically RCI with heavy covering. Weld metal flows readily; light slag easily removable	Weld and repair gray iron castings; faster than oxyacetylene for repairing small defects
RCI-A	Alloy cast iron	Oxyacetylene	Similar to RCI but higher melting. Weld metal more fluid; welding more rapid	Gray or alloy cast iron to obtain greater tensile strength and finer grain structure than RCI
RCuZn-A[c]	Naval brass	Oxyacetylene	Better strength, corr res than basic 60 Cu-40% Zn alloy. Deposits 70–90 Bhn	Where color match is not required and weldments are not subject to electrolytic corrosion or high temperature service
RCuZn-B[c]	Manganese bronze	Oxyacetylene	Better strength, hardness, corr res than 60 Cu-40% Zn alloy. Deposits 80–110 Bhn	Same as above
RCuZn-C[c]	Low-fuming bronze	Oxyacetylene	Diminishes zinc oxidation (fuming). Slightly higher mechanical properties than naval brass or manganese bronze; deposits 80–110 Bhn	Same as above
RCuZn-D[c]	Nickel bronze	Oxyacetylene	Color is silver rather than yellow. Low fuming. Deposits 90–110 Bhn	Same as above
ECuAl-A2[d], RCuAl-A2[c]	Aluminum bronze (9–11 Al, 1.5% Fe)	Electrodes—arc welding; a.c. and d.c. reversed polarity. Rods—carbon arc welding	Low m.p. permits rapid welding to minimize distortion. Yld and ten str twice those of ECuSn alloys (below)	Weld the new higher strength cast irons. Overlay corrosion and wear resistant surfaces
ECuSn-A[d]	Phosphor bronze (4.8–5.8% Sn)	Arc; d.c. reversed polarity	Deposits 70–85 Bhn	Weld cast iron and overlay bearing and corrosion resistant surfaces
ECuSn-C[d]	Phosphor bronze (7.0–9.0% Sn)	Same as above	Deposits 85–100 Bhn. Higher yld and ten str than ECuSn-A	Same as above
ENi	Nickel	Arc; flat specified but other positions have been used	Rapid, widely used. Even without preheating, deposits can be machined	Weld ordinary gray irons to themselves or to other ferrous and nonferrous materials; light and medium-sized castings. Reclamation and repair
ENiFe	Nickel-iron	Same as above	Same as above, but higher ten str and ductility	Weld various cast irons to steel and other ferrous and nonferrous materials; heavy and highly stressed sections. Better than ENiFe for castings containing more than 0.20% P
ENiCu-A	Nickel-copper (55–60% Ni)	Same as above	Similar to ENiFe	Similar to ENiFe
ENiCu-B	Nickel-copper (63–70% Ni)	Same as above	Similar to ENi	Similar to ENi
ESt	Mild steel	Arc; a.c. or d.c. reversed polarity	Designated specifically for cast iron; has a low m.p. Covering and deposits not readily machinable	Largely confined to repair of small pits and cracks in cast iron; some larger repairs if casting requires no machining

[a] Chemical symbols for the major elements of the composition are used to classify these rods and electrodes. In other cases, CI = cast iron and St = steel. The letter, or letter and number, following the hyphen indicates a modification of a standard composition.
[b] For exact chemical composition as manufactured, see ASTM A398-56T.
[c] Also a standard classification under Copper and Copper Alloy Welding Rods.
[d] Also a standard classification under Copper and Copper Alloy Welding Electrodes.

Other welding processes. Each process has variants not described and less commonly used. There are also special processes such as *flow welding*, *forge welding*, *thermit welding* and *induction welding*. All of these are described in detail in the *Welding Handbook* of the American Welding Society.

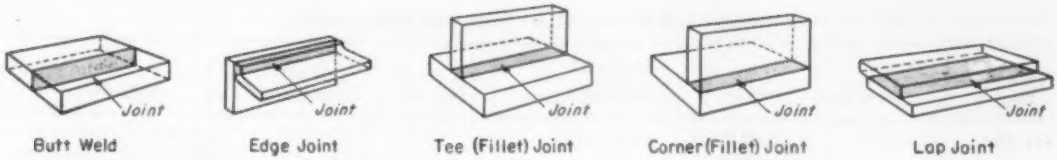


Fig 1—The five basic welding joint designs.

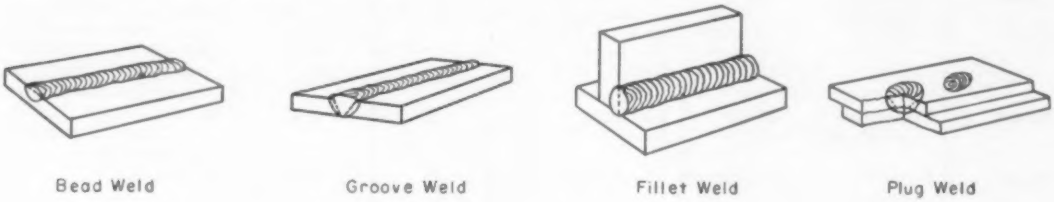


Fig 2—The four basic weld types for arc and gas welding.

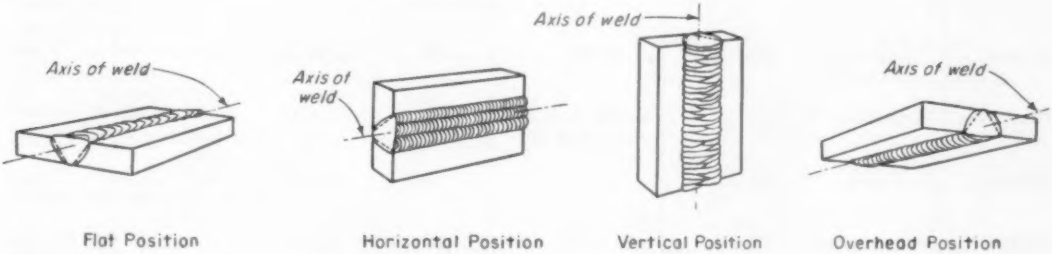


Fig 3—The four basic welding positions.

5—RODS FOR GAS WELDING IRONS AND STEELS [a]

AWS-ASTM Class ↓	Weld Treatment[b]	Min Ten Str, 1000 psi	Min Elong (in 2 in.), %
GA65	SR	65	20
	NSR	72	17
GA60	SR	60	25
	NSR	62	20
GA50	SR	50	28
	NSR	52	23
GB65	SR	65	18
	NSR	72	15
GB60	SR	60	20
	NSR	62	15
GB45	NSR	45	—

[a] Mechanical tests are performed on welds made by either 3/16- or 1/4-in. rods and on plates 3/8 in. thick (except GB45 which requires a 3/8-in. plate).
[b] SR = stress relieved; NSR = non-stress relieved

Design Factors

Welding is a basic production method whose end product is a metal part or form termed a "weldment." Weldments must be considered in competition with castings, forgings and other fabricated forms, as well as other joining methods.

Sizes and shapes. A wide range of thicknesses, sizes and shapes can be joined by welding. Parts as thin as 1 mil and as thick as 20 in. have been welded commercially. Plate and sheet stock are the most widely used forms, but forgings, castings, extrusions and rolled shapes are also used in fabricating weldments.

Tolerances. The two principal factors influencing tolerances are distortion from the welding operation and the tolerances of the metal forms that make up the weldment. The tolerances on the various metal forms, such as flat stock, castings, forgings and rolled sections, are easily obtainable. But degree of welding distortion is a function of a great many things, and exact values cannot be given. The following tolerances seem to be those most commonly achieved:

1. Small parts containing very little welding, 1/8 in.
2. Moderately large parts containing a small amount of welding, 1/4 in.
3. Large structures containing moderate amounts of welding, 3/8 in.
4. Large, complicated structures, and structures containing large amounts of welding, 3/8 to 1/2 in.

continued on next page

Welding Electrodes and Rods

6—COPPER AND COPPER ALLOY RODS AND ELECTRODES

AWS-ASTM Class ↓	Common Name	Welding Method[a]	Current, Polarity	Min Ten Str, 1000 psi	Brinell Hardness	Applications
ECu, RCu....	Copper	IGMA (E, R), CA (R), OG (R)	D.c. straight	25	25–40[b]	Light gage Cu up to 3/16 in.—R[c]; heavier gage—E. Deoxidized Cu (R)[c,f]
ECuSi, RCuSi-A....	Silicon bronze (Si 2.8–4.0%)	IGMA (E, R), SMA (E), CA (R), OG (R)	D.c. reverse (E), d.c. straight (R)	50	80–100	Primarily for welding Cu, CuS and CuZn to themselves (E, R) and to steel (R)[c,f]. Mtl over 1/16 in. thk (E).[d] Silicon bronze; overlay for corr res (E)[g]. CuSi alloys (R)[c]
RCuSi-B......	Silicon bronze (Si 1.02–2.0%)	CA, OG	D.c. straight	35	60–85	Red brass piping[e]. Cu, CuSi and CuZn[f]; Cu to steel[f]; galvanized iron[f]
RCuSn.......	Phosphor bronze (Sn 4.0–6.0%)	CA, IGMA-NC	D.c. straight	35	70–85	Cu[c,f] and CuSn[c]
ECuSn-A[i]....	Phosphor bronze (Sn 4.8–5.8%)	SMA, IGMA-C	D.c. reverse	35	70–85	Weld phosphor bronzes of similar comp. "A" and "C" (below) used interchangeably for Cu, brasses, bronzes, cast iron, dissimilar metals
ECuSn-C[i]....	Phosphor bronze (Sn 7.0–9.0%)	SMA, IGMA-C	D.c. reverse	40	85–100	Same as above, but "C" provides higher ten and yld str, higher hardness
ECuNi, RCuNi	Copper nickel	SMA (E), OG (R), IGMA-NC(R)	D.c. reverse (E), d.c. straight (R), a.c. (R)	50	60–80	CuNi alloys (10–30%) to themselves to provide good corr res
RCuZn-A[i]....	Naval brass	BW, OG	—	50	70–90	Brass[e]. Cu, bronze, Ni alloys, steel, cast and malleable iron[h]
RCuZn-B[i]....	Manganese bronze	BW	—	55	80–110	Steel and cast iron[h]. As surfacing filler metal for building up bearings
RCuZN-C[i]....	Low-fuming bronze	BW, OG	—	57	80–110	General purpose
RCuZn-D[i]....	Nickel bronze	BW, OG	—	60	90–110	Steel and cast iron[h]
ECuAl-Al, RCuAl-Al...	Aluminum bronze (iron-free)	IGMA (E, R), CA (R)	D.c. reverse (E), a.c. (R)[c], d.c. straight (R)[c,f]	55	100–158 (E), 100–130 (R)[f], 100–150 (R)[c]	Annealed aluminum bronze plate, sheet and strip (E, R). Repair castings (E, R)[c,f]. Overlay bearing and corr res surfaces (E, R)[c]
ECuAl-A2[i], RCuAl-A2[i].	Aluminum bronze (Fe 3.0–4.25%)	IGMA (E, R), SMA (E), CA (R)	D.c. reverse (E)[d,g], d.c. straight (R)[c,f], a.c. (E[g], R[c])	60 (E), 65 (R)	130–150 (E)[g], 150–170 (E)[d], 100–130 (R)[d], 100–150 (R)[c]	Aluminum bronze, high str CuZn alloys, silicon bronze, nickel alloys, ferrous alloys, dissimilar metals. Repair castings; overlay bearing and corr res surfaces
ECuAl-B, RCuAl-B...	Aluminum bronze (Fe 3.0–4.25%)	SMA (E), CA (R), IGMA-NC(R)	D.c. reverse (E), d.c. straight (R)[c,d], a.c. (E, R[c])	65 (E), 70 (R)	140–180 (E), 140–180 (R)[f], 180–220 (R)[c]	Similar to above, but provides higher phys prop. Weld nonferrous metals to steel (E,R)[c]

[a] Method symbols are: IGMA = inert-gas metal arc welding (–C = consumable electrode; –NC = nonconsumable electrode); OG = oxyacetylene welding, CA = carbon arc welding, SMA = shielded metal arc welding (covered electrodes), BW = braze welding.
[b] Rockwell F.
[c] Inert-gas metal arc (nonconsumable electrode) welding.
[d] Inert-gas metal arc (consumable electrode) welding.
[e] Oxyacetylene welding.
[f] Carbon arc welding.
[g] Shielded metal arc welding (covered electrode).
[h] Braze welding.
[i] Also a standard classification under Rods and Electrodes for Welding Cast Iron

Joint design. There are five fundamental types of arc or gas welded joints (see Fig 1) and four basic types of welds (see Fig 2), but variations of these are used to satisfy particular requirements. Resistance welding commonly employs the lap joint, although flash welding requires a butt joint.

Welding positions. Welds are classified by four basic positions; for each, certain electrodes are recommended or not recommended. The position terms—flat, vertical, horizontal and overhead—can be applied to all types of welds, but they are illustrated here for the groove weld (see Fig 3).

7—NICKEL AND NICKEL ALLOY COVERED ELECTRODES[a]

AWS-ASTM Class[b] ↓	Alloy	Common Name	Min Ten Str, 1000 psi
E3N10.........	Nickel-copper (C 0.40, Mn 4, Cb+Ta 0%)	Monel[c,d]	70
E3N11.........	Nickel (C 0.75)	Nickel[e]	55
E3N12.........	Nickel-chromium-iron	Inconel[e]	80
E3N14.........	Nickel-copper-aluminum	K monel[e]	100[f]
E3N19.........	Nickel-chromium-iron-titanium	Inconel X	115[f]
E3N1B, E4N1B..	Nickel-molybdenum	Hastelloy B[g]	100
E3N1C, E4N1C..	Nickel-molybdenum-chromium	Hastelloy C[g]	100
E4N10.........	Nickel-copper (C 0.15, Mn 2.50, Cb+Ta 3%)	Monel	—
E4N11.........	Nickel (C 0.10%)	Nickel	—
E4N12.........	Nickel-chromium	Inconel	—

[a] Used with shielded metal arc welding process.
[b] These electrodes are used to join alloys of same composition as the electrode. When first digit of designation is *3*, electrode is used primarily to join similar alloys to themselves; when first digit is *4*, electrode is used to weld a nickel or nickel-base alloy to steel, to overlay a nickel or nickel-base alloy on steel, or to weld the clad side of nickel or a nickel-base alloy clad steel.
[c] Used to weld not only mill products but also castings of suitable welding quality.
[d] Also used to weld such copper-nickel alloys as 70–30, 80–20 and 90–10 to themselves.
[e] Also used for a number of dissimilar metal combinations.
[f] Age hardened.
[g] Also used to weld alloys of similar composition to steel-clad materials or other metals.

8—NICKEL AND NICKEL ALLOY RODS AND BARE ELECTRODES

AWS-ASTM Class[a] ↓	Alloy	Common Name	Welding Method[b]
RN40........	Nickel-copper (Mn 2, Al 0, Ti 0)	Monel	OG[c]
ERN60.......	Nickel-copper (Mn 1, Al 1.25, Ti 1.50–3.00)	Monel	IGMA, At. H_2
RN41........	Nickel (Mn 0.35, Fe 0.40, Ni 97 min, Al 0, Ti 0.50)	Nickel	OG[c]
ERN61.......	Nickel (Mn 1, Fe 1, Ni 93 min, Al 1.50, Ti 2.00–3.50)	Nickel	IGMA, At. H_2
RN42........	Nickel-chromium-iron (Ni 72 min, Cb+Ta 0)	Inconel	OG, IGMA[d]
ERN62.......	Nickel-chromium-iron (Ni 70 min, Cb+Ta 1.50–3.00)	Inconel	IGMA, At. H_2, OG
RN43........	Nickel-copper-silicon	—	OG[e]
ERN64.......	Nickel-copper-aluminum	K Monel	IGMA, At. H_2[f]
ERN69.......	Nickel-chromium-iron-titanium	Inconel X[g]	IGMA, At. H_2[f]
ERN6N.......	Nickel-chromium-titanium	Nimonic 7s	IGMA, At. H_2
ERN7B.......	Nickel-molybdenum	Hastelloy B	At. H_2, IGMA, Sub Arc
ERN7C.......	Nickel-molybdenum-chromium (Cr 14.5–16.5, Mo 15–17, W 3.00)	Hastelloy C	At. H_2, IGMA, Sub Arc
ERN7W......	Nickel-molybdenum-chromium (Cr 4–6, Mo 23–26, W 0)	Hastelloy W[h]	At. H_2, IGMA, Sub Arc

[a] These rods and electrodes are used to weld alloys of similar composition.
[b] For the IGMA process, argon and d.c. reversed polarity are preferred for electrodes; either argon or helium and d.c. straight polarity with rods. Welding method symbols used are: OG = oxyacetylene; IGMA = inert-gas metal arc; At. H_2 = atomic hydrogen; Sub Arc = submerged arc.
[c] Gross porosity usually results when arc welding is employed.
[d] Do not use inert-gas metal arc method on sheet 1/8 in. thick and heavier.
[e] Used to weld monel which has 55–60% Ni, or any monel when absence of flux desirable.
[f] Responds to age hardening.
[g] Used to weld Inconel X and Inconel W.
[h] Used to weld such dissimilar metal combinations as Cr-Ni-Fe steels to cast cobalt alloys.

9—ALUMINUM AND ALUMINUM ALLOY RODS AND ELECTRODES

AWS-ASTM Class ↓	Major Composition As Manufactured	Alloys Welded[a]
BARE ELECTRODES AND RODS[b]		
R-996A, E-996A......	Al 99.6 min	996A
R-990A, E-990A......	Al 99.0 min	990A, M1A, G1A, clad M1A
R-C4A..............	Cu 4.0–5.0	CS42A, C4A
R-CN42A............	Cu 3.5–4.5, Ni 1.7–2.3	CN42A
R-CS41A, E-CS41A...	Cu 3.9–5.0, Si 0.50–1.2	Clad CS41A
R-G1A, E-G1A.......	Mg 1.0–1.8	M1A, G1A, clad M1A
R-GM50A, E-Gm50A.	Mg 4.9–5.6, Mn 0.05–0.20	MG11A, Gr20A, clad MG11A, GS42A, GS11A
R-GR20A, E-GR20A.	Mg 2.2–2.8, Cr 0.15–0.35	MG11A, GR20A, clad MG11A
R-GR40A, E-GR40A..	Mg 3.1–3.9, Cr 0.15–0.35	MG11A, GR20A, GS11A, clad MG11A, GS42A, GR40A
R-MG11A, E-MG11A.	Mn 1.0–1.5, Mg 0.8–1.3	MG11A, clad MG11A
R-S5B, E-S5B.......	Si 4.5–6.0, Bi 0.05	M1A, MG11A, G1A, GR20A, CS11A, clad M1A, clad MG11A, S5A
R-SC51A............	Si 4.5–5.5, Cu 1.0–1.5	SC51A
R-SG70A............	Si 6.5–7.5, Mg 0.20–0.40	SG70A
R-ZG61A............	Zn 5.2–6.0, Mg 0.50–0.65	ZG61A
COVERED ELECTRODES[c]		
Al-2................	Al 99.0 min	Pure aluminum (min ten str 12,000 psi)
Al-43..............	Si 4.5–6.0, Al bal	General purpose (min ten str 14,000 psi)

[a] These ASTM alloy designations apply to all forms except die castings.
[b] Welding methods include gas, shielded carbon arc, inert-gas metal arc and atomic hydrogen.
[c] Used with d.c. current, preferably in flat position.

Adhesives

Selection

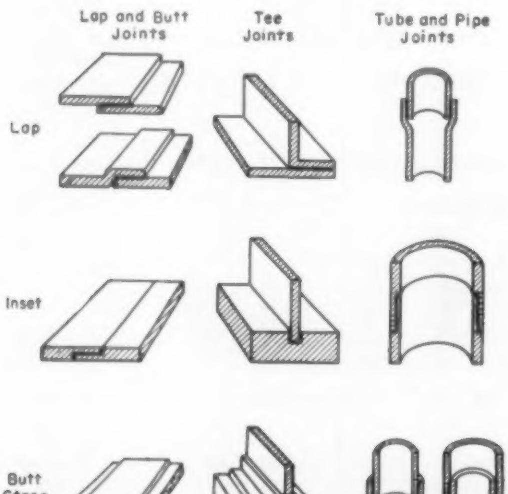
Classification. There are many ways to classify adhesives, none of which is satisfactory by itself. The five tables included here, each using a different breakdown, must therefore be referred to as a group. Classifying by chemical composition (Table 1) is most usual, but the newer modified compounds are omitted because they represent the blending of several chemical groups, and because the use of tradenames often obscures the chemical designation. In addition, in only a limited sense is the relationship between the type of materials being joined and the chemical type of the modified compounds a factor in selecting the adhesive.

These new adhesive "alloys" include: phenolic elastomers (e.g., phenolic-neoprene, phenolic-Buna N); vinyl phenolics (phenolic-vinyl, phenolic-polyvinyl butyral, phenolic-polyvinyl formal); modified epoxies (epoxy-phenolic, epoxy-polyamide, epoxy-polysulfide).

The other four tables apply to the single-resin adhesives as well as to these new modified compounds. In addition there are two factors which must be given more attention than the tables indicate:

Time. All classifications (as well as tack and bond strength properties) are related to time in various ways—shelf and pot life, tack life, length of time of application of heat and pressure, time lapse before handling parts, time lapse before end service.

End service conditions. Only by knowing and considering all the factors of end service, as well as all factors discussed in the tables here, can the formulator recommend a particular chemical composition with particular bonding requirements, vehicle, form and flowability. New formulations are devised where necessary. Also, it is not uncommon to use *two* adhesive formulations (allowing the first to dry before applying the second) to obtain the desirable advantages of each, or to obviate an undesirable effect of contact between the second adhesive and the surface.



Some examples of good joint design.

Definitions

Emulsion. Adhesive type in which basic resin is a water-insoluble liquid (or solid particles) stably dispersed in water. Emulsifying agents are added to decrease surface tension. Some emulsions also contain a small amount of solvents (5%) to increase tackiness and improve water resistance.

Glue line thickness. Thickness of the fully dried adhesive layer.

Lay down thickness. Thickness of the applied wet adhesive coating.

100% reactive. Also "100% solids." Generally a modified epoxy resin-base paste, this adhesive type contains no solvent and cures at room temperature or higher.

Pot life. Length of time adhesive remains usable after being put into serviceable condition.

Shelf life. Length of time adhesive can be stored without deterioration (also known as "can stability").

Solvent dispersion. Adhesive type in which basic resin is in solvent solution and bonding is done by evaporation of the solvent (solvent release). A wide variety of solvents are used: ketones, toluol, naphtha, hydrocarbons, alcohol, acetone, etc. Solvent content generally varies from 10 to 50% for thermoplastic and thermosetting adhesives, from 50 to 95% for elastomeric.

Tack. The charateristic ("stickiness") that causes one surface, coated with adhesive, to adhere to another upon contact. Tack time may range from a few seconds to an almost indefinite period.

Wet strength. The bond strength realized immediately after adhesive-coated surfaces are joined and before cure occurs.

Methods

Adhesive bonding lends itself to complex automatic set-ups using spray guns, flow guns, paint rollers, etc. to apply the adhesive; pressure rolls, heavy presses, ovens, autoclaves, etc. to develop the bond. However, hand bonding with solvent-dispersed adhesives is common, and an understanding of the five steps involved can be applied to other methods:

1. Surface preparation—Surfaces should be smooth; must be clean and dry. Precleaning generally involves abrasive or chemical cleaning (ceramics, metals), light sanding (wood), chemical removal of mold release or plasticizer bloom (rubber, plastics), etc.

2. Adhesive preparation—Placing adhesive in a serviceable state may require mixing, thinning, reactivating, etc.

3. Applying adhesive—Varies from sticking coated film or tape or nameplate in place to use of trowel, squeeze bottle, hand roller, brush, etc.

1—CLASSIFIED BY CHEMICAL COMPOSITION GROUP

Type ➔	Natural	Thermoplastic	Thermosetting	Elastomeric
Examples of Type	Casein, blood albumin, hide, bone, fish, starch (plain and modified); rosin, shellac, asphalt; inorganic (sodium silicate, litharge-glycerin)	Polyvinyl acetate, polyvinyl alcohol, acrylic, cellulose nitrate, asphalt, oleoresin	Phenolic, resorcinol, phenol-resorcinol, epoxy, urea, melamine, alkyd	Natural rubber, reclaim rubber, butadiene-styrene (GR-S), neoprene, acrylonitrile-butadiene (Buna-N), silicone
Most Used Form	Liquid, powder	Liquid, some dry film	Liquid, but all forms common	Liquid, some tape
Common Further Classifications	By vehicle (water emulsion is most common but many types are solvent dispersions)	By vehicle (most are solvent dispersions or water emulsions)	By bonding requirements (heat and/or pressure most common but some are catalyst types)	By bonding req (all are common). Also by vehicle (most are solvent dispersions or water emulsions)
Bond Characteristics	Wide range, but generally low strength; good res to heat, chemicals	Good to 150–200 F; poor creep strength; fair peel strength	Good to 200–500 F; good creep strength; fair peel strength	Good to 150–400 F; never melt completely; low strength; high flexibility
Major Type of Use	Household, general purpose, quick set, long shelf life	Unstressed joints; designs with caps, overlaps, stiffeners	Stressed joints at slightly elevated temp	Unstressed joints on lightweight materials; joints in flexure
Materials Most Commonly Bonded	Wood (furniture), paper, cork, liners, packaging (food), textiles, some metals and plastics. Industrial uses giving way to newer types, esp in woodworking	Formulation range covers all materials, but emphasis on nonmetallics, esp wood, leather, cork, paper, etc., because these are less likely to require stressed joints	Depends greatly on specific type: epoxies for dissimilar materials and plastics; phenolics for metal, glass and wood; ureas and melamines extensively for wood; alkyds for metal laminations.	Few used "straight" for wood, rubber, fabric, foil, paper, leather, plastics films; also as tapes. Most modified with synthetic resins

2—CLASSIFIED BY BONDING TYPE[a]

General Type ⬇	Specific Types Available[b]	Forms Used	Remarks
Heat	Rm temp to 450-F types available; 250 to 350-F types most common	Formulated in all forms; liquid most common	Applying heat will usually increase the bond strength of any adhesive, even rm temp types
Pressure	Contact to 500-psi types available; 25 to 200-psi types most common	Formulated in all forms; liquid + powder most common	Pressure types usually have greater strength (not true of modified epoxies)
Time	Types requiring a few seconds to a week available; ½ to 24-hr types most common	Formulated in all forms	Time required varies with pressure and temp applied and immediate strength
Catalyst	Extremely varied in terms of chemical catalyst required; may also contain thinners, etc.	Two components—paste (or liquid) + liquid	Sometimes catalyst types may require elevated temp (<212 F) and/or pressure instead of, or in addition to, a chemical agent
Vulcanizing	Varied types requiring addition of a chemical agent (usually sulfur); may also contain a catalyst	Two liquid components	Premixed types requiring 250 to 350 F for vulcanization are available
Reactivation	Types requiring heat or solvent or second coating of adhesive	Dry film or previously applied liquid	Heat type is best for nonporous surfaces and/or max strength

[a] Formulations may be a combination of two or more of these types.
[b] Types stated as being most common refer to modified or "alloy" adhesive compounds.

4. Assembly—Accomplished during tack life of adhesive (5 min to 1 hr for porous surfaces, but can be extended) or after reactivating dried coating.

5. Bond development—Drying out of the solvent usually takes 1 to 60 min. Heat can be applied by warm air, infrared lamps or hot plate; pressure by

Adhesives

3—CLASSIFIED BY VEHICLE*

Type →	Solvent Dispersion	Water Emulsion	100% Reactive ("100% solids")
Form	Liquids, pastes, tapes, supported films	Liquids	Pastes, films
Adhesive Alloy	Elastomer (rubber or vinyl butyral) + thermosetting resin (phenolic, sometimes epoxy or alkyd)	Reclaimed rubber + asphalt; milk latex	Usually modified epoxies (others for films)
Bonding Requirements	Usually pressure and/or heat, solvents (reactivation type)	Heat and/or pressure	Contact pressure; choice of rm temp or heat curing
Advantages	Flowability; easy to apply in film or tape form and from dispensing bottles. Can be reactivated after drying. Allows widest choice to formulator	Most inexpensive of the three. Eliminates fire hazard. Consistency can be varied by adding water	No time wait for solvent release. Eliminates fire hazard. No attack on vulnerable adherends. High heat resistance. Fills voids
Limitations	Care must be taken to allow for solvent release if both surfaces are nonporous (not usually recommended). Solvent may interact unfavorably with certain plastics	Usually limited to bonding where at least one surface is nonporous. Some types require high pressure. Freezing damages bonding properties	Peel, stretch and impact properties not usually as high as in others. Not freely flowing. Usually supplied as two-component adhesive requiring mixing. High shear strength falls rapidly above specified temp
Remarks	Elastomer adds flexibility, peel and impact strength	Curing characteristics highly influenced by added modifiers	Highly suited for metal-to-metal bonds, electrical uses

* This method of classification is the most common for modified compounds, but omits "contact-bond" and "pressure-sensitive" adhesives. Contact-bond adhesives adhere to themselves for a specified period of time after the coating has dried. Pressure-sensitive types adhere to almost any surface for an almost indefinite period of time after drying.

4—CLASSIFIED BY FORM

Type ↓	Remarks	Advantages
Liquid	Most common form; practically every formulation available. Principally solvent-dispersed	Easy to apply. Viscosity often under control of user. Major form for hand application
Paste	Wide range of consistencies. Limited formulations; principally 100% solids modified epoxies	Lends itself to high production set-ups because of less time wait. High shear and creep strengths
Powder	Require mixing or heating to activate curing	Longer shelf life; mixed in quantities needed
Mastic	Applied with trowel	Void-filling, nonflowing
Film, tape	Limited to flat surfaces, wide range of curing ease	Quick and easy application. No waste or run-over; uniform thickness
Other	Rods, supported tapes, precoated copper for printed circuits, etc.	Ease of application and cure for particular use

weighted hand rollers, metal weights or squeeze rolls. With nonporous surfaces, solvent must be dried out before final assembly pressure; for such application heat reactivation types are often used (applying heat and/or pressure after assembly of dried coated parts), but stronger bonds are developed by using 100%-reactive adhesives rather than solvent-dispersed.

5—CLASSIFIED BY FLOWABILITY*

Type ↓	Form or Vehicle Type	Advantages
Flow	Liquid, light or heated pastes, solvent dispersion, water emulsion	Fills crevices, fills complex joints, evens glue line, smooths surface
Nonflow	Heavy paste, trowelable mastic, void-filling epoxy, 100% solids	Applies vertically, requires no "clean-up," fills voids and gaps, does not sag

* There is no fine line of distinction between these types. In addition, flowability is affected by such factors as: temperature, pressure, joint design, time left standing, mixing of catalysts or solvents.

Joint Design

Joints should be designed to keep the adhesive in shear and avoid cleavage and peel stresses. Typical good joint designs are shown by the accompanying sketches.

The type of strength under consideration (particularly peel vs shear) is extremely important in adhesive bonding.

Joint properties are also a function of the thickness of the glue line. Shear and creep strength are highest for thin films (0.001 to 0.003 in.), but heavier films may exhibit higher flexibility, toughness and cleavage strength.

Because there are so many factors involved in adhesive selection, compromise may be necessary. To aid the formulator in making this compromise, and to minimize cost, safety factors included in specifications should be only as high as absolutely necessary.

Mechanical Fasteners

Mechanical fastening is the most versatile and most widely used method for joining materials and parts. In the broadest sense, mechanical fasteners can be classified in two groups: threaded types (semipermanent) and rivets (permanent).

Threaded Fasteners

Types. The accompanying table describes the most common types of threaded fasteners (including washers). Some other types include:

Screws—In addition to variations (e.g., spanner heads, wing heads, split points), of every screw described, there are many special types, such as: sealing, twin head, one-way set and load-indicating.

Bolts—Many special head variations are available for the bolts described. Two important types not listed are sealing bolts (designed with an integral rubber washer under the head) and blind bolts (expander nut pulled back into sleeve by hydraulic gun, then core bolt inserted). Still more specialized bolts include: track, blow, tap, bent, load-indicating, crating, rib, and drive and locking stud bolts.

Nuts—There are nuts to mate with almost every type of bolt described. Other types include: acorn, anchor, clinch weldments (attached by spot welding), roofing, wing or thumb, and grommets.

Washers—Special types include: countersunk, sealing, sleeve, load-indicating, pipe and laminated.

Thread series. Most common threads are designated "Unified" and are either "coarse" or "fine," depending on the number of threads per inch for a specific diameter. The coarse series is for general use where quick assembly is desired; the fine series for aeronautical and similar work. Uniform pitch series (e.g. 8-thread) are also standard and widely used in special applications.

Thread class. Class refers to the tolerance in manufacture and to the allowances permissible. The majority of screws and bolts are produced to class 2A (external tolerances and positive allowances); nuts to 2B (internal tolerances). Where closeness of fit is required, classes 3A and 3B may be used. Various fits are obtained by combining male and female threads of different classes.

Materials. Although the use of low carbon steel is widespread, all common metals, as well as some thermoplastics, are used in critical applications. To obviate galvanic corrosion, it is often desirable to use fasteners made from a material similar to those being joined. However, the corrosive effect must be weighed against such factors as increased strength and greater holding power.

Screws—Carbon and stainless steels, brass, silicon bronze and aluminum are often standard or available on order. Special materials available in limited types include die cast zinc alloys and several thermoplastics (nylon is most common). Zinc and cadmium-plated screws are often standard, and other electroplates are available on order. Other finishes and coatings include anodized, carbonized and black oxide.

Bolts and nuts—Carbon, alloy and stainless steels are standard for almost every type, but brass, naval bronze, monel and aluminum are often standard as well. Special materials available in some types include: malleable iron, silicon bronze, titanium, sintered brass, nylon and other thermoplastics. Finishes and coatings include those available for screws. Nuts, however, are often supplied with one of the following additional finishes: nickel and silver-plated, molybdenum disulfide, chromate, phosphate, and chromium oxide diffusion.

Washers—Most standard nut materials are also used for washers. Special materials include chromium-molybdenum steel, galvanized steel, vulcanized fibre and extruded nylon. Sealing washers generally are rubber—natural, silicone, neoprene or nitrile. Standard electroplated finish is usually cadmium, but zinc, nickel, tin, copper and chromium are not uncommon. Other finishes include phosphate and oil.

Design. Details of design depend upon many factors, including the type, style and material of the fastener which has been selected after consideration of end service conditions, materials being joined, speed and ease of assembly required, and ease and frequency of disassembly required. Loading should be in shear rather than tension. When assembly of the fastener requires that pressure, sharp blows or torque be applied to one side of the joint, that side should be the one having the thicker or harder material.

Descriptive nomenclature. Threaded fasteners are available with many types of shanks, heads, locking devices, etc.—some standardized and many not—which makes it impractical to define the hundreds of terms used. In addition, fastener terminology is apt to be overlapping, making it difficult, in theory, to distinguish between such items as bolts and screws, or machine screws and certain cap screws. Recent standards, for instance, include stove bolts with machine screws.

In the accompanying tables types have been distinguished according to general practice, rather than theory, as much as possible. In addition, the word "top" has been coined. Industry uses the word "head" for two purposes: to refer to the shape (generally as viewed from the side), and to refer to the design for a particular tool (generally recognizable by viewing from the top). The word "top" used in the tables refers to the latter. For example, a slotted round head (round as viewed from the top and slotted on top for a conventional screwdriver) is listed here as: top—slotted, head—round.

Rivets

Riveting is the fastest production fastening method of producing fairly strong joints with unskilled labor, yet with a high degree of consistency. Rivets are driven either hot or cold, by hammering or peening or by applying steady pressure from one or both sides. The shear strength of solid rivet joints is equal to or higher than that of many common threaded fasteners. Tubular and split are lower in strength, particularly tensile.

Design factors are similar to those for threaded fasteners. Joints are either lap or butt (using butt strap). Minimum recommended rivet spacing is usually three times the body diameter of the rivet. Allowable distances from edges are usually based on the rivet body diameter; 1½D for hot-driven rivets and 2D for cold-driven.

Materials from which rivets are fabricated include iron, low carbon steel, stainless steel, brass, copper, monel, aluminum, nickel silver and several thermoplastics. Coatings and finishes of all types can be ordered.

The table on p 453 describes the most common types of rivets.

tables start on next page

Mechanical Fasteners

THREADED FASTENERS—SCREWS

Type ↓	Description	Made of . . .	Selection Features	Uses
Wood	Top—slotted or cross-recessed. Head—flat, round or oval. Thread—single, some double; point—gimlet. Also drive screws, hanger bolts, dowel screws	Low and medium carbon steels; alloy and stainless steel, monel, others	General use	Wood, and thin sheets of other material to wood
Cap	Top—hex or fluted socket; head—smooth or knurled. Top—slotted; head—round, flat, fillister or hex. Thread—coarse or fine; 8-thread; point-chamfer. Also top—plain; head—hex or knurled	Carbon and stainless steel, brass, bronze, monel, aluminum	General use with tapped holes or nuts. Shank usually not fully threaded. Socket type (most used) has closer fit than machine screws	Fastening metal parts and components
Machine	Top—slotted or cross-recessed; head—round, flat, oval, undercut (flat or oval), fillister, truss, binding or pan. Also hex heads, tops plain or slotted. Thread—coarse or fine; point—sheared	Carbon and stainless steel, brass, silicon bronze, monel, aluminum	Same as cap, but usually full-thread shank and smaller dia. Slotted type most used, generally with nut	Same as cap
Tapping (thread-forming)	ASA "A": Top—slotted or recessed; head—flat, oval, round, pan, fillister, truss or hex; thread—spaced; point—gimlet. "B": Same but blunt point. "BP": Same but cone point. "C": Same but blunt tapered point and machine thread	Case hardened steel; others on special order	A—general sheet metal screw; B—heavier duty; BP—misaligned parts; C—higher strength	All—Sheet metal, wood, asbestos, cloth to sheet metal. C—Cast iron, die cast zinc, steel, bronze and brass forgings, plastics
	Drive screws. 1) Top—plain; head—round; point—dog; thread—multiple with large helix angle. 2) Top—plain; head—pan; point—cone; thread—annular in upper section, but lower section has multiple threads with large helix angle	Case hardened steel; others on special order	Forms mating thread as hammered or pressed; can be applied with hopper-fed machines	Permanent fastenings. 1) Castings, heavy-gage sheet, plastics. 2) Fabric, leather or fiber to sheet metal
Thread-Cutting	ASA "D", "F", "G" and "T": Top—slotted or recessed; head—flat, oval, round, pan, truss or hex; thread—machine; point—blunt. Types differ in cutting edge: D—one off-center slot; F—several flutes; C—one centered through-slot; T—one wide slot. ASA "BF", "BG" and "BT" similar to F, G and T, respectively, but have spaced thread	Case hardened steel; stainless steel on special order	Minimum driving torque; fewer chips; increased resistance to stripping out	As above, but thin sections, particularly bosses in brittle plastics, plywood
Lock	Various proprietary types, such as: 1) preassembled lead washer; 2) variation of A.N. thread form; 3) longitudinal insert; 4) nylon pellet insert; and 5) annular expansion insert. Other types include: preassembled screw and lock washer, screw with locking teeth under head, slotted head fitting into counterbored hole with insert forced into slot. Also, liquid sealants used with standard screws	1—Heat treated alloy steel. 2—All std screw mtls. 3—Steel (incl stainless), brass, aluminum; insert is fluorocarbon plastic. 4—Carbon and stainless steel, aluminum alloy, brass, bronze. 5—Heat treated alloy steel; insert is bronze	1—Washer extrudes around tapered head. 2—Locks on full length of thread by reforming mating thread. 3—Insert does not project, has gradual torque build-up. 4—Insert projects slightly, locks whether or not screw is seated. 5—Insert expands when compressed, remains when screw is removed	Widely used, esp in mass production. Various types allow joining all metals and many plastics. Particular use depends on such factors as: permanent or disassembly; ease of assembly; amount of torque to assemble or disassemble; type of stress—rotational, vibration, thermal; sealing properties

THREADED FASTENERS—BOLTS AND NUTS

Type ↓	Description	Made of . . .	Selection Features	Uses
Regular (general use)	External hexagon or square head, generally used with nut of same shape. "Regular"—unfinished (not machined on any surface except threads); coarse threads. "Regular semifinished"—bolt heads and nuts are machined on bearing surface to provide washer face (or nuts may have chamfered corners); coarse threads. "Finished"—same as regular semifinished but closer body tolerance; threads—coarse, fine and 8-thread. Std. machine screw nut is "regular"	Carbon and alloy steel, stainless steel, brass, naval bronze, monel, aluminum	Longer bolts are similar to hexagon cap screws, shorter to hexagon machine screws, but the hex head is more common with bolts, as is the use of nuts. Bolts come in greater standard lengths, are sturdier and are classified differently	Widely used for all materials. For larger parts and greater stresses than screws. Where material too soft or hard, or too thin, to be tapped. Where threaded shanks easily accessible
Jam Nut	Similar to Regular or Heavy, but thinner	Same as above	Lower ten str than above	Often used with full nut for locking action
Lag Screw	Head—square; point—gimlet or cone. Also known as lag bolt	Low carbon steel	—	Fasten wood together or any material to masonry
Round Head Bolt	Two body styles (std dia and undersized) with coarse threads. Bolts include: 1) round head, square neck; 2) round head, short square neck; 3) round head, ribbed neck; 4) round head, fin neck; 5) 114-deg-countersunk square neck; 6) round head; 7) elevator (flat, large dia head; square neck); 8) ribbed head—slotted and unslotted; 9) step (like elevator but round head); 10) countersunk	Carbon and alloy steel, stainless steel, brass, naval bronze, monel, aluminum	These bolts differ in the method used to prevent rotation during bolting. Each is inserted in a hole which mates with the neck. Head types are selected by appearance or need for flush tops	For 1) wood, 2) steel, 3) hard wood and plastics, 4) wood, 5) wood, 6) any material where there is no other way to prevent rotation, 7) soft materials, 8) flooring, 9) resilient materials to steel, 10) metal to wood
Stud Bolt (stud)	A stud is a rod threaded either completely or on both ends. Types include: tap end (one end to produce interference fit in tapped hole, other for nut); double end (both ends for nuts); continuous thread; hangar bolt (one end has lag screw thread)	Low carbon steel	Advantageous where length adjustment desirable	Widely used for castings (permanently assembled) and for soft metal and plastic parts
Place Bolt	Flexible zone is formed by slotted segments in the upper face of a hex bolt head and a circular recess in the lower face, providing a controlled spring action which increases elastic elongation	Carbon and alloy steel; others available	Provides resistance to loosening by vibration and minimizes fatigue failure	Cylinder heads, flywheel housings, bearings (cap screw), connecting rods
Locknut	Huge variety of proprietary locknuts, most of which can be classified as one of the following types: 1) free-spinning (no locking action until seating begins, e.g., integral toothed washers), 2) prevailing torque (locking depends on some form of interference between male and female threads, e.g., deforming threads or forcing lead or angle), 3) spring action (designed to take advantage of natural spring of the material or with auxiliary springs, e.g., slotted segments; arched base with prongs to lock against threads)	Nuts—carbon steel generally std; also stainless, brass, monel, aluminum. Springs—heat treated spring steel usually std; also stainless, brass, phosphor bronze, beryllium copper. Inserts—bronze usually std; also brass, aluminum, steel	Locknuts remain tight under vibration and replace the use of wire or cotter pins in a hole drilled through bolt and nut. Each type designed for specific use in terms of materials, end service conditions, ease of assembly, etc.	Mass produced automobiles, appliances, machinery, aircraft, furniture, toys, etc.

continued on next page

Mechanical Fasteners

THREADED FASTENERS—WASHERS AND INSERTS

Type ↓	Description	Made of . . .	Selection Features	Uses
Plain Washer	Plain, flat, circular washer standardized in o.d. and i.d. dimensions (ASAB27.2-1958) and with suggested thicknesses. Form series are: light, medium, heavy, extra heavy	Almost all materials used for nuts	Provide increased bearing surface for bolt heads or nuts, thus distributing load over larger area. Also prevent marring, improve appearance	Widely used with nuts and bolts
Lock Washer	Split spring type. Washer is split and shaped like a single turn of a slight helix. Free height is about twice the washer thickness; gap is small enough to prevent entangling	Carbon steel, stainless 302 or 420, aluminum-zinc alloy, phosphor and silicon bronze, K monel. Not all materials in all four series	Prevents loosening of bolt under vibration. Split-spring type allows occasional disassembly and reassembly; tang of helix may mar work surface	Widely used for most plain threaded screws and bolts
	Tooth type. Teeth on i.d., o.d. or both. Variety of shapes and tooth types designed for specific uses	Carbon steel, phosphor bronze	Same as above, but thinner than split-spring, not recommended for frequent disassembly	External tooth type for bolts; internal tooth type for screws
	Spring type. Some proprietary types: domed, conical, waved, countersunk, cap, folded rim, tab, irregular hole, wood spring	Medium carbon and stainless steel, bronze, aluminum, beryllium, copper, K monel	Provides strong locking with varied other features	Special uses, generally on softer materials
Insert	May be threaded bushings, studs, etc., cast or molded integrally with part. Many proprietary inserts are molded in or inserted after part is formed. Noncircular cross sections resist turning; undercuts resist tensile pull. Some types are: 1) slotted body, exterior fins, 2) slotted and tapered body containing four-eared disk below threaded portion, 3) spool-shaped spacer, 4) helical coil of diamond-shaped wire (also locking type with center loop of coil octagon-shaped), 5) disk-shaped with edge groove around middle, 6) threaded, with embedded nylon pellet, 7) two-piece: threaded insert and lock ring	1) Aluminum alloy, 2) brass, 3) aluminum alloy, 4) stainless, phosphor bronze, Hastelloy C, 5) brass, steel, stainless, aluminum, 6) low carbon steel, 7) low carbon steel. Most inserts can be obtained in other materials, e.g., brass, bronze, aluminum, monel	Added strength for soft materials. 1) Allows expansion pressure against hole and screw. 2) Disk is forced down to spread four tapered segments. 3) Through-bolt or threaded. 4) Coil has both internal and external thread; inserted in tapped hole. 5) Locked by swaging tool. 6) Uses standard screwdriver. 7) Outer teeth of lock ring broach into parent material	Limited to parts thick enough to hold insert. 1) Wood, plastics, soft metals. 2) Replace molded-in inserts. 3) Sandwich panels. 4) Where weight and wear are problems; used in damaged tapped holes. 5) Plastics sheet, soft sheet metal. 6) Nonferrous metals. 7) Hard materials (resists vibration and stress); soft materials (resists wear)

RIVETS, STITCHING AND STAPLING

Type ↓	Description	Uses
RIVETS		
Large Solid	Dia from ½–1¾ in. Head—button, high button, cone, pan or countersunk (flat or round). Neck—straight or swell (exc countersunk). Special heads include: machine, globe, wheel, trunk. Steel is standard material; others available	High production, permanent assembly operations requiring high tensile and shear strength and generally not requiring airtight or watertight joints. Aircraft, ships, trains, bus and truck bodies, etc.
Small Solid	Head—flat, countersunk, button, pan, truss, tinners', coopers' or belt	As above (generally cold riveting is used on small rivets, hot riveting on large)
Semi-Tubular	Shallow hole, extruded or drilled in shanks, does not exceed shank dia. Variety of heads include: oval, flat countersunk, tinners', cone	Where stress is low, or primarily shear. Metals, ceramics, hard plastics and woods; through predrilled or prepunched holes. Aircraft, cameras, toys
Tubular	Hole in shank is deeper than dia but less than ½ in. Rivet compresses material within shank. Head variety same as above	Where stress is low, or primarily shear. Leather, soft plastics, rubber, soft woods, fabrics. Leather cases, golf bags, sheet metal
Split	Slot milled in shank forms two sharp prongs that pierce material without weakening it	Where stress is low, or primarily shear. Light-gage metal, plastics, wood, fibreboard, leather
Shouldered	Shoulder beneath head is made to spec. Either coldformed or coldheaded and turned	Where pivot or bearing surface req within joined members. Automotive parts, vending machines
Blind	Proprietary types, of which most are one of these: 1) sleeve—either hollow (mandrel pulled back through; may be plugged if desired), or self-plugging (after mandrel is pulled through it is trimmed off to leave solid rivet); 2) pin driven through tapered hole in rivet to expand it, then lip peened over pin head; 3) type for which a special assembly tool is basic, e.g., a gun grips pull-through mandrel, clinches rivet, continues to pull until head or stem breaks; 4) explosive charge contained within shank is detonated (by riveting iron, etc.) to expand rivet to fill hole and form bulb on end. Materials are: cadmium-plated steel, aluminum alloy, brass, stainless, monel, etc.	Where backing up the rivet is impractical, usually due to inaccessibility. 1) Lends itself esp to automatic setting; hollow is not as strong but can be plugged by any mtl desired and with umbrella head to match design. 2) High shear str, good ten str. 3) High assembly rate; rivet has high str clinch but is not completely hole-filling. 4) Extremely high assembly rate; widely used to fasten both metals and nonmetallics; nearly equiv in str to solid rivet
Other	Some special rivets are: outside prong, compression, decorative spot, precious metal, brake lining	Special uses
METAL STITCHING AND STAPLING		
Stitching and Stapling	Joining two or more materials with 18-gage wire fed from a coil, cut to length, formed, driven through and clinched. High assembly rate, but limited to thin parts, e.g., joining 0.093-in. aluminum strips. Loop clinches are best for nonstructural joints, flat clinches for stressed. Stapling differs in using preformed fasteners. Std mtls include high carbon steel, stainless, and phosphor bronze	For sheet and strip stock of all materials, but preferably joining soft nonmetallics to metal. Also sandwich materials

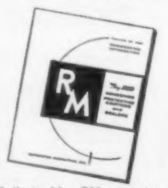
Characteristics of typical Raybestos-Manhattan *Ray-BOND*® Adhesives

NUMBER	TYPE	CHARACTERISTICS	USES
R-81001 R-81002 R-81008	Thermosetting synthetic rubber, synthetic resin; heat setting. Solids range from 18 to 40%.	Flexible, resistant to oils, solvents; requires heat and pressure for cure.	For bonding metals, plastics, friction materials to themselves or to each other. Not recommended for use on assemblies where bond line temp. might exceed 400°F for prolonged periods in application. Short term to 600°F.
R-82004	Synthetic rubber, synthetic resin; emulsion adhesive; cold setting; solvent evaporation type.	Flexible, good peel strength, medium drying; gains strength upon loss of solvent; exhibits good strength up to 270°F for nonstructural applications.	For bonding nonporous or semiporous materials to themselves and to various metals—plastics, decorative metal parts, leather, etc.
R-82005 R-82006 R-82007 R-82008	Synthetic rubber, synthetic resin; solvent evaporation type. Solids range from 17 to 30%.	Flexible, good peel strength, quick drying; gains strength upon loss of solvent; not to be used on parts that might be subjected to temperatures in excess of 180°F; sprays well.	General laminating adhesive for plywood, chipboard, hardboard, paper and metal honeycomb, composition base materials to each other or to rigid plastic and metal.
R-82013	Synthetic rubber, synthetic resin; cold setting or heat setting.	Flexible, good peel strength, quick drying; gains strength upon loss of solvent.	General-purpose adhesive for nonstructural parts. Vinyl (PVC) to plastic, metal, cloth, and buna-N type rubbers to metal or to themselves.
R-84001 R-84002	Synthetic resin; hot melt type.	Flexible, to be heated to 250-300°F and applied. Strength obtained upon cooling. Ball and ring melt test, 205°F.	General purpose adhesive for bonding most materials including mylar and polyethylene. Recommended as a nonstructural adhesive for applications where the bond line temperature will not exceed 200°F.
R-84029	Synthetic resin; heat setting.	Heat resistant to 650°F; some degree of flexibility; resistant to oils, solvents, water, brake fluids.	For bonding friction material to friction material or to steel where some degree of flexibility is desired.
R-86008	Synthetic resin; 2-component system.	Good electrical properties, low shrinkage. Heat distortion point of 178°F. Pot life 30 min.	Casting, encapsulating and potting. Metal to metal, ceramic to metal, glass to metal.
R-86009	Synthetic resin; 2-component system.	Salt water resistant; semi-flexible; room temperature curing.	Bonding rubber to rubber, metal or wood. Cyclizing necessary for optimum results.
R-86020	Special synthetic resin; single component system.	High tensile strength; excellent resistance to most chemical acids and alkalies. Heat resistant to 400°F; unlimited pot life.	For bonding metal to metal, ceramic to metal, metal to plastics.
R-86044	Special synthetic resin base; 2-component system.	Room temp. curing; 40 min. working life.	For bonding etched Teflon to metal, glass to glass, where optimum chemical resistance is desired.
R-87001	Synthetic rubber base.	Good adhesion; high peel strength up to 270°F; contains no flammable solvents.	For bonding fabrics to fabrics.

RAYBESTOS-MANHATTAN manufactures these 7 classes of adhesives, coatings and sealers:

1. Heat setting, synthetic resin adhesives, coatings, and sealers (not epoxy)
2. Cold setting, synthetic resin adhesives (not epoxy)
3. Heat setting, synthetic resin, synthetic rubber adhesives
4. Cold setting, synthetic resin, synthetic rubber adhesives
5. Rubber base adhesives
6. Synthetic resin sealants, and coatings (not epoxy)
7. Epoxy base adhesives, coatings and sealers; casting, encapsulating and potting compounds

Experienced Raybestos-Manhattan technicians will give you the benefits of more than 20 years of experience in the production of bonded assemblies and the manufacture of adhesives, coatings and sealers. They will provide you with full technical information and recommendations on the latest methods proved most efficient in many successful applications. Why not call on Raybestos-Manhattan engineers today to cut costs or improve production in your operations.



R/M Bulletin No. 701 contains helpful engineering information on Ray-Bond adhesives, protective coatings and sealers. Write for your free copy.

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Facts you should know about

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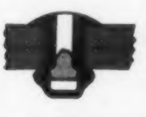
"POP" Rivets are high strength, precision-made hollow rivets assembled on a solid mandrel. Used in "blind" and "non-blind" applications. Made in a complete range of sizes and head styles in aluminum, monel, steel and copper. Available in both "Open-End" and "Closed-End" types.

CLOSED-END "POP" RIVETS



Seal as they set. Designed to provide a pressure and vapor tight seal. Ideal for tanks, vessels, or applications where weather tightness is required. Available with domed or countersunk heads in a wide range of sizes and grip lengths.

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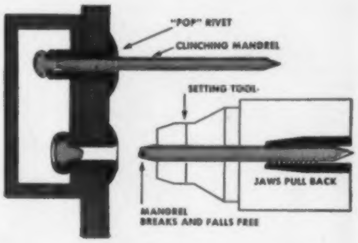
HOW "POP" RIVETS WORK



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- Allows more compact designs — less back-up space required. Only 3/16" needed on "blind" side.
- Reduces weight and material costs by allowing use of thinner sheets. Hold tight even in .020 aluminum. No stripping or distortion.
- Resists corrosion by eliminating surface marring and chipping.
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- Allows use of non-critical hole diameters which assures strength to satisfy design considerations combined with speed of assembly.
- Complete selection of hand and power tools available for production rates to 1200 rivets per hour.

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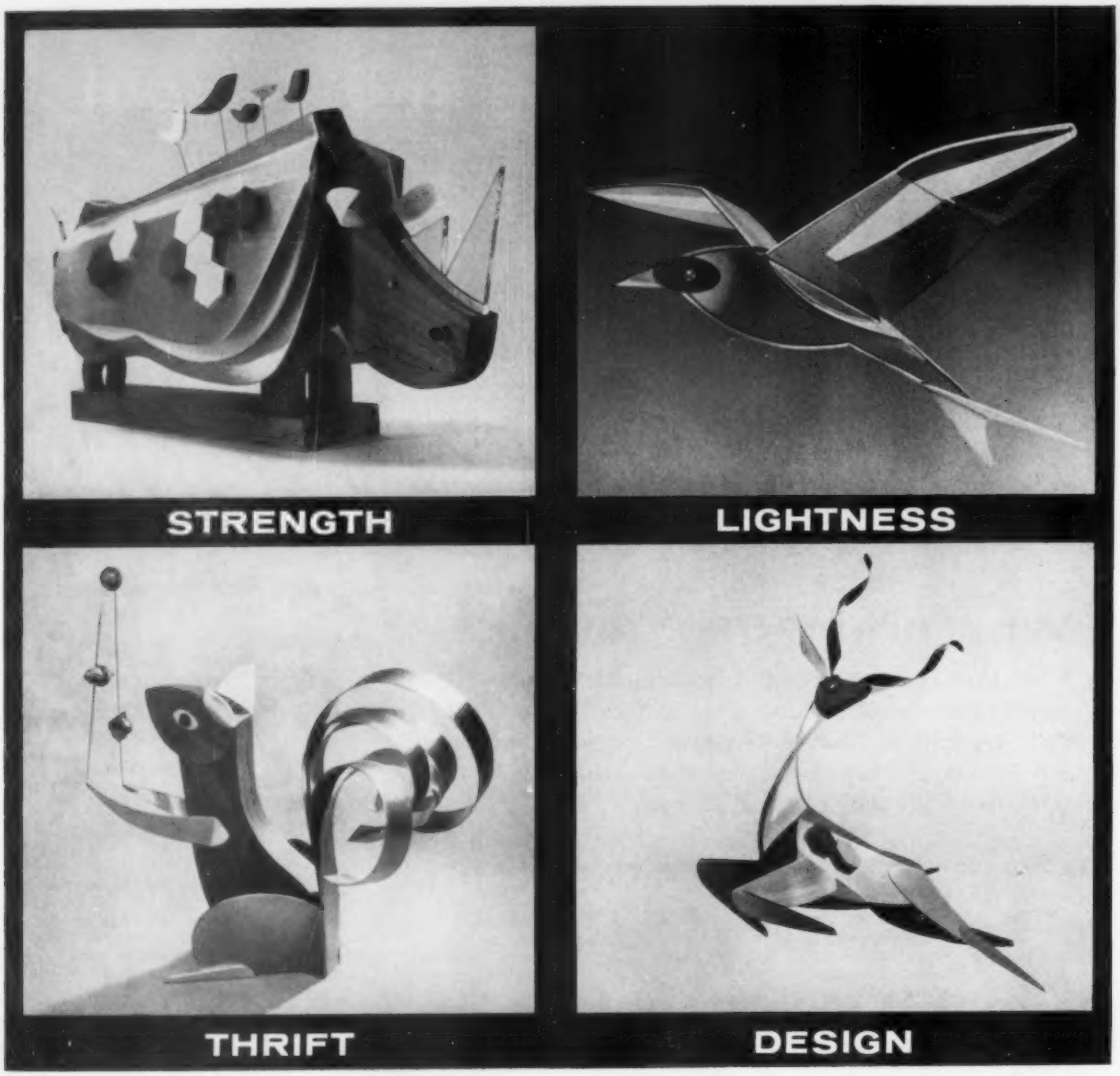

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MINNESOTA MINING AND MANUFACTURING COMPANY

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HANDY ALLOY DATA SHEET

HANDY & HARMAN ENGINEERING DEPARTMENT
850 THIRD AVENUE, NEW YORK 22, N.Y.

ALLOY LIST

Handy & Harman Silver Brazing Alloys

...The COMPLETE line that meets all specifications and production needs

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HANDY & HARMAN SILVER BRAZING ALLOYS

NAME	COMPOSITION PERCENTAGE Ag	Cu	Zn	Other	MELTING POINT °F	°C	FLOW POINT °F	°C	TROY OUNCES PER CU. IN.
EASY-FLO	50	15½	16½	(18 Cd)	1160	625	1175	635	5.0
EASY-FLO 3	50	15½	15½	(16 Cd-3 Ni)	1170	630	1270	690	5.0
EASY-FLO 45	45	15	16	(24 Cd)	1125	605	1145	620	4.9
EASY-FLO 35	35	26	21	(18 Cd)	1125	605	1295	700	4.9
SIL-FOS	15	80		(5 P)	1185	640	1300	705	4.5
SIL-FOS 5	5	89		(6 P)	1185	640	1300	705	4.4
TEC*	5			(95 Cd)	640	340	740	395	4.6
TEC-Z*	5		16.6	(78.4 Cd)	480	250	600	315	4.5
BRAZE ATT	20	45	30	(5 Cd)	1140	615	1500	815	4.6
" 202	20	45	35		1315	715	1500	815	4.7
" NT	30	38	32		1250	675	1410	765	4.7
" DT	40	36	24		1235	670	1415	770	4.8
" SS	40	30	28	(2 Ni)	1220	660	1435	780	4.8
" 404	40	30	25	(5 Ni)	1220	660	1580	860	4.7
" DE	45	30	25		1225	665	1370	745	4.8
" ETX	50	34	16		1250	675	1425	775	5.0
" 541	54	40	5	(1 Ni)	1340	725	1575	855	5.1
" 560	56	22	17	(5 Sn)	1145	620	1205	650	5.0
" 580	57½	32½		(7 Sn-3 Mn)	1120	605	1345	730	5.1
" RT	60	25	15		1245	675	1325	720	5.0
" 603	60	30		(10 Sn)	1115	600	1325	720	5.2
" 630	63	28½		(6 Sn-2½ Ni)	1275	690	1475	800	5.1
" EASY	65	20	15		1240	670	1325	720	5.1
" MEDIUM	70	20	10		1275	690	1360	740	5.1
" BT	72	28			1435	780	1435	780	5.2
" HARD	75	22	3		1365	740	1450	790	5.3
" 752	75		25		1300	705	1330	720	5.1
" IT	80	16	4		1340	725	1490	810	5.3
" 852	85			(15 Mn)	1760	960	1780	970	5.1
PREMABRAZE 615	61.5	24		(14.5 In)	1155	625	1305	705	5.0

*A Solder—Not a Brazing Alloy.

Space does not permit listing the many special alloys formulated for a particular or unique application. Handy & Harman Brazing Engineers and Technical Service are always ready to work closely with you on metal joining problems and methods. Specific data sheets on any of these alloys await your request.

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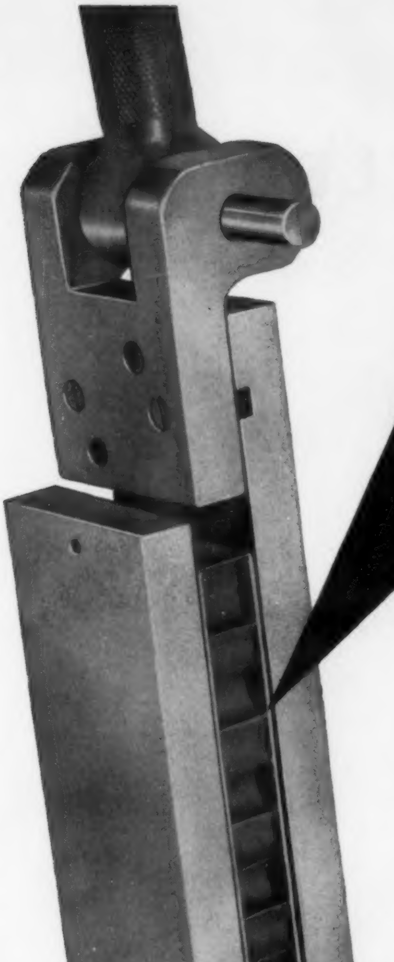

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DIRECTORY SECTION

THE DIRECTORY SECTION

This Directory Section is designed to be a comprehensive and up-to-date source of suppliers of engineering materials, forms, finishes and closely related services. The listings were compiled from information received from more than 3000 manufacturers, from official information made available by trade associations, and from many other sources.

HOW TO USE THE DIRECTORY SECTION

The Directory Section consists of two sections. In the first, the categories of materials, forms, finishes and related services are arranged alphabetically; suppliers in each category also are listed alphabetically with their geographical location indicated by state abbreviations. The many cross references make it easy to find any given category. In general, suppliers of basic or "mill" forms of materials, such as sheet, are listed under the particular materials, whereas suppliers of "fabricated" forms, such as forgings, are listed under the form.

Key letters in parenthesis following names of suppliers provide two kinds of additional information: 1) the basic materials in which a supplier furnishes a particular fabricated form, and 2) the basic forms in which a supplier furnishes a particular material (see key at right). For example, if you are looking for suppliers of magnesium sand castings, you will look for those suppliers of sand castings whose names are followed by the letter "e." Similarly, if you are looking for suppliers of cellulose acetate rod, you will look for those suppliers of cellulose acetate whose names are followed by the letters "bb."

Further information on a particular supplier's product can often be found by consulting an advertisement in this issue. Advertisers' names are bold-faced under the appropriate categories, and the pages on which their advertisements appear are listed following their names. Page numbers of advertisements are also given in the complete Index to Advertised Products, p 7, and the complete Index to Advertisers, pp 8-10.

The second part of the Directory Section contains a complete alphabetical list of suppliers and their addresses. To find the address of a division of a company, look up the name of the parent company (always given with the division name in the first part of the Directory Section).

In compiling a directory of this nature it is impossible to avoid errors and omissions. We will welcome corrections and suggestions. Please address them to Directory Section Editor, MATERIALS IN DESIGN ENGINEERING, *430 Park Ave., New York 22, N. Y.*

The listings and other data in this directory section are compiled from sources believed reliable by the publisher. The publisher, however, does not represent or guarantee the accuracy of said listings and data, and no responsibility is assumed therefor.

MATERIALS

a Aluminum and its alloys
b Copper and its alloys
c Iron and its alloys (except steel)
d Lead and its alloys
e Magnesium and its alloys
f Nickel and its alloys
g Steels
h Titanium and its alloys
j Zinc and its alloys
k Thermoplastics
l Thermosetting plastics
m Elastomers

BASIC FORMS

n Anodes
o Bar
p Base resins, polymers or gums
q Billets
r Custom formed parts (incl. specialties)
s Fibers
t Film
u Foams (component materials or products)
v Foil
w Ingot
x Laminating, casting resins
y Molding compounds
z Plate
aa Powder
bb Rod
cc Sheet
dd Strip
ee Tubing
ff Wire

SUPPLIERS OF MATERIALS

ABS

(acrylonitrile-butadiene-styrene)
Acushnet Process Co., Mass (y)
Anchor Plastics Co., Inc., NY (bb, dd,ee)
Bolta Products Div., General Tire & Rubber Co., Mass (cc)
Cadillac Plastic & Chemical Co., Mich (cc)
Colonial Plastics Mfg. Co., Div. of Van Dorn Iron Works Co., Ohio (bb,cc,dd)
Conneaut Rubber & Plastics Co., Div. of U. S. Stoneware Co., Ohio (bb, cc,dd,ee)
Crane Plastics, Inc., Ohio (bb,dd,ee)
Crescent Plastics, Inc., Ind (ee)
Denver Plastics Inc., Colo (bb,cc,dd,ee)
Goodrich, B. F. Chemical Co., Ohio
(p,y)—Ad pp 266-267
Hall Mfg. Corp., NJ (dd,ee)
Kaufman Glass Co., Del (bb,cc,dd, ee)
Lus-Trus Corp., Mich (dd,ee)
Madin Plastics Inc., NJ (y,cc)
Marbon Chemical Div., Borg-Warner Corp., Ind
(y)—Ad pp 231-238
Monsanto Chemical Co., Plastics Div., Mass
(p,y)—Ad pp 212-213
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,y)
Nixon-Baldwin Chemicals, Inc., NJ (cc)
O'Sullivan Rubber Corp., Plastics Div., Va
(t,cc)—Ad p 215
Polymer Chemical Co., Ohio (x)
Prince Rubber & Plastics Co., Inc., NY (bb,cc,ee,)
Southern Plastics Co., SC (bb,cc,dd, ee)
Sperry Rubber & Plastics Co., Ind (dd,ee)
Stokes Molded Products Div., Electric Storage Battery Co., NJ
U.S. Rubber Co., Royalite Plastic Products Div., Ill (cc)
Western Plastics Corp., Wash (ee)
Western Textile Products Co., Mo (ee)
Woodall Industries, Inc., Mich (cc)

Acetal Plastics

Albany Novelty Mfg. Co., Mass (t,cc)
Anderson Assoc., Inc., Ohio (y)
Bamberger, Claude P., Inc., NJ (y)
Belding Corticelli Industries, NY (y)
Cadillac Plastic & Chemical Co., Mich (o,z,bb)
Celanese Polymer Co. Div., Celanese Corp. of America, NJ
(p,y)—Ad pp 224-225
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Davis, Joseph Plastics Co., NJ (t,y, bb,cc,dd,ee)
du Pont de Nemours, E.I. & Co., Inc., Del
(p,t,x,y)—Ad pp 247-248
Heyden Newport Chemical Corp., American Plastics Corp. Div., NY (bb,cc,dd,ee)
Hyde, A. L. Co., NJ
(bb,cc)—Ad p 408
National Vulcanized Fibre Co., Del (bb,cc,ee)
Pennsylvania Fluorocarbon Co., Inc., Pa (ee)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Shawinigan Resins Corp., Mass (p)
Superior Plastics, Inc., Ill (bb,cc,ee)

Acetate

(see Cellulose Acetate)

Acrylate Rubber

(see Acrylic Rubber)

Acrylic Plastics

Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
American Molding Powder & Chemical Co., NY (y)
American Products Mfg. Co., Inc., La (t,bb,cc)
Anchor Plastics Co., Inc., NY (bb,dd, ee)
Anderson Assoc., Inc., Ohio (y)
Artus Corp., NJ (cc,dd)
Auburn Plastic Engineering, Ill (bb, cc,ee)
Auburn Plastics, Inc., NY (bb,dd,ee)
Baker, J. T. Chemical Co., NJ (p,y)
Bamberger, Claude P., Inc., NJ (y)
Blank, Arthur & Co., Inc., Mass (cc)
Borden Co., Borden Chemical Div., NY (p)
Cadillac Plastic & Chemical Co., Mich (bb,cc,dd,ee)
Cast Optics Corp., NJ (cc)
Catalin Corp. of America, NY (p)
Chemical Development Corp., Mass (p)
Colonial Kolonite Co., Ill (bb,cc,ee)
Colton Chemical Co., Div. of Air Reduction Co., Inc., Ohio (p)
Comco Plastics, Inc., NY (bb,cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)
Crane Plastics, Inc., Ohio (bb,dd,ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (bb,cc,dd,ee)
Denver Plastics, Inc., Colo (bb,cc,dd, ee)
De Soto Chemical Coatings, Inc., Ill (p)
Dow Chemical Co., Plastics Div., Mich (s)
du Pont de Nemours, E.I. & Co., Inc., Del (p,s,x,y)
Dura Plastics of New York, Inc., NY (bb,cc,dd,ee)
Durable Formed Products, Inc., NY (cc,ee)
Dyna-Therm Chemical Corp., Calif (p)
Eljay Corp., Md (bb,cc,dd,ee)
Foss Mfg. Co., Id (cc)
Freeman Chemical Corp., Wis (p)
Fry Plastics International, Calif (bb, cc)
Galigher Co., Utah (bb,cc,dd,ee)
General Aniline & Film Corp., NY (cc)
General Plastics Corp., Ind (cc)
General Plastics Mfg. Co., Wash (bb, cc,dd,ee)
Gering Plastics, Div. of Studebaker-Packard Corp., NJ (y,bb,dd,ee)
Glass Laboratories, Inc., NJ (bb, dd, ee)
Grigoleit Co., Ill (p,s)
H & R Plastics Industries, Inc., Pa (bb,cc,dd,ee)
Hall Mfg. Corp., NJ (dd,ee)
Heyden Newport Chemical Corp., American Plastics Corp. Div., NY (bb,cc,dd,ee)
Industrial Plastics Corp., Ind (bb,dd)
Jet Specialties Co., Inc., Calif (bb, dd,ee)
K S H Plastics, Inc., Mo (bb,cc,dd)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Luminous Resins, Inc., Ill (y)
Lus-Trus Corp., Mich (cc,ee)
Midwest Plastic Products Co., Ill (cc, dd)
Muehlstein, H. & Co., Inc., NY (p, y,cc)
Norrich Plastics Corp., NY (bb,cc,ee)
Perfex Plastics, Inc., Ill (bb,dd)
Philrus Products Co., NJ (bb,cc,dd, ee)
Plast-Ad Mfg. Co., Ind (bb,cc,dd,ee)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Plastic Compounding Corp., Sub. of Plastiglide Mfg. Corp., Calif (y)
Plastic Materials, Inc., NY (y)
Polycast Corp., Conn (cc)
Pyramid Industries, Inc., Pa (ee)
Reed Plastics Corp., Mass (y)
Rohm & Haas Co., Pa (y,cc)
Russell Mfg. Co., Conn (s)
Schwab Plastics Corp., Mich (bb,cc, dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Snyder Mfg. Co., Inc., Ohio (cc)
Southern Plastics Co., SC (bb,cc,dd, ee)
Superior Plastics, Inc., Ill (bb,dd)
Union Carbide Corp., Union Carbide Chemical Co. Div., Textile Fibers Dept., NY (s)
United Shoe Machinery Corp., Mass (p)
Walton Gibb Leather Co., Inc., Pa (cc)
Western Felt Works, Ill (cc)
Westlake Plastics Co., Pa (t,y,bb,cc, dd,ee)
World Plastics, NY (bb,cc,dd,ee)

Acrylic Rubber

Adhesive Products Corp., NY (x)
Bond International, Inc., Mich (y,ee)
Borden Co., Borden Chemical Div., NY (p)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Ill (p)
Colonial Rubber Co., Ohio
(y,cc)—Ad p 416
Continental Rubber Works, Pa (bb, cc,dd,ee)
Dow Chemical Co., Plastic Div., Mich
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
Dyna-Therm Chemical Corp., Calif (p)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (y,cc,ee)
Flexible Tubing Corp., Conn (ee)
Garlock Packing Co., NY (y,cc)
General Plastics Mfg. Co., Wash (bb, cc,dd,ee)
Goodrich, B.F. Chemical Co., Ohio (p,cc)
Maloney, F.H. Co., Tex (y)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Norrich Plastics Corp., NY (bb,cc,dd, ee)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (y)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Polymer Chemical Co., Ohio (x)
Roth Rubber Co., Ill (cc)
Russell Mfg. Co., Conn (s)
Southern Plastics Co., SC (bb,cc,dd,ee)
Vulcan Div., Reeves Bros., Inc., NY (p,y,cc)
Wasco Products, Inc., Mass (cc)
Western Backing Corp., Calif (y)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Acrylonitrile-Butadiene Rubber

Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NY (bb,cc,dd)
American Rubber Products Corp., Ind (u,bb,cc,dd,ee)
Anderson Assoc., Inc., Ohio (y)
Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Bond International, Inc., Mich (y,ee)
Borden Co., Borden Chemical Div., NY (p)
Buffalo Weaving & Belting Co., NY (cc)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Ill (p)
Colonial Rubber Co., Ohio
(y,cc)—Ad p 416
Continental Rubber Works, Pa (bb,cc, dd,ee)
Dayton Rubber Co., Ohio (y,bb,cc,dd, ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
Faultless Rubber Co., Ohio (y,bb,ee)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (y,cc,ee)
Firestone Tire & Rubber Co., Ohio (p)
Flexible Tubing Corp., Conn (ee)
Garlock Packing Co., NY (y,bb,cc,dd, ee)
Geauga Industries Co., Ohio (y,bb,dd)
Goodrich, B.F. Chemical Co., Ohio (p, cc)
Goodyear Tire & Rubber Co., Chemical Div., Ohio (p)
Goshen Rubber Co., Inc., Ind (y)
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd,ee)
Lee Rubber & Tire Corp., Republic Rubber Div., Ohio (p,y,cc,dd,ee)
Luzerne Rubber Co., NJ (bb,cc,dd,ee)
Maloney, F.H. Co., Tex (y)
Marbon Chemical Div., Borg-Warner Corp., Ind (p,x,y)
Martin Rubber Co., Inc., NJ (y,dd,ee)
Mid-States Rubber Products, Inc., Ind (y)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,y)
Paeco Rubber Co., Inc., Ohio (y,dd,ee)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (y)
Parker, Stearns & Co., Inc., NY (y, bb,cc,dd,ee)
Polymer Chemical Co., Ohio (x)
Prince Rubber & Plastic Co., Inc., NY (bb,cc,ee)
Raybestos-Manhattan, Inc., Plastic Products Div., Pa (x)
Roberts Toledo Rubber Co., Ohio (ee)
Roth Rubber Co., Ill (y,cc)
Rubatex Div., Great American Industries, Inc., Va (u)
Saran Lined Pipe Co., Div. of Michigan Pipe Co., Mich (y,cc)
Sheller Mfg. Corp., Mich (u)
Southern Plastics Co., SC (bb,cc,dd, ee)
Sperry Rubber & Plastics Co., Ind (dd,ee)

Stockwell Rubber Co., Inc., Pa (y,bb, cc,dd)
Technical Specialties Co., NY (dd)
Toyad Corp., Pa (u)
Trostel, Albert Packings, Ltd.,Wis (y)
U.S. Rubber Co., NY (p)
Vulcan Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Backing Corp., Calif (y)
Western Felt Works, Ill (y,cc,dd,ee)
Westlake Plastics Co., Pa (bb,cc,dd)
Williams-Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Adhesives

(see also Tapes)

Adhesive Products Corp., NY (k,l,m)
Alcylite Plastics & Chemical Corp., Calif (k,l)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (l)
American Cyanamid Co., Plastics & Resins Div., NY (l)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l,m)
American Metaseal Corp., NJ (l)
American Products Mfg. Co., Inc., La (k,m)
American Sealants Co., Conn (l)
Angier Adhesives Div., Interchemical Corp., Mass (k,l,m)
Arabol Mfg. Co., NY (k)
Argo Plastic Products Co., Ohio (k,l)
Aries Laboratories, Inc., Conn (l)
Armour & Co., Adhesive Div., Ill (k, m)
Armstrong Cork Co., Pa (k,l,m)
Armstrong Products Co., Ind (l)
Atlantic Bag Co., NY (l)
Avery Label Co., Calif (l)
Avondale Co., Ill (k,l,m)
B. B. Chemical Co., Bostik Dept., Mass.
(k,l,m)—Ad p 464
Babbitt Chemical Co., Inc., Mass (k)
Beck, I. & Sons, Inc., NY (m)
Belding Corticelli Industries, NY (k,l, m)
Belko Corp., Md (m)
Biggs, Carl H. Co., Inc., Calif (k,l)
Bisonite Co., Inc., NY (l)
Borden Co., Borden Chemical Div., NY (k,l,m)
California Metal Enameling Co., Calif (k,m)
Campro Co., Ohio (k)
Capac Mfg. Corp., Mich (k,l,m)
Catalin Corp. of America, NY (l)
Cellcote Co., Ohio (k,l,m)
Chemgineers, Inc., Calif
Chemical Coatings & Engineering Co., Inc., Pa (k,l,m)
Chemical Development Corp., Mass (k,l)
Chemical Process Co., Calif (l)
Chemical Products Corp., RI (k,m)
Chrysler Corp., Cycleweld Div., Mich (k,l,m)
Clinton Co., Ill (k,l,m)
Coast Pro-Seal & Mfg. Co., Calif (l,m)
Colonial Kolonite Co., Ill (k)
Connecticut Hard Rubber Co., Conn (m)
Continental Can Co., Conolite Div., Del (l)
Cooper, Peter Corp., NY (k)
Co-Polymer Chemicals Inc., Mich (l)
Cordo Chemical Corp., Conn (k,l,m)
CrystalX Corp., Pa (k)
Dacar Chemical Products Co., Pa (k, l,m)
Dayton Rubber Co., Ohio (k,l,m)
Dennis Chemical Co., Mo (k,m)
Devcon Corp., Mass (k,l)
Douglas & Sturgess, Calif (l,m)
Dow Corning Corp., Mich (m)
du Pont de Nemours, E.I. & Co., Inc., Del (k)
Durable Formed Products, Inc., NY (k)
Dyna-Therm Chemical Corp., Calif (k,l,m)
Eastman Chemical Products, Inc., Sub. of Eastman Kodak Co., NY (k)
Electro Chemical Engineering & Mfg. Co., Pa (k,l,m)
Electronic Production & Development, Inc., Chemical Div., Calif (l)
Emerson & Cuming, Inc., Mass (k,l,m)
Everlite Corp., Wash (k,l,m)
Fanner Mfg. Co., Munray Products Div., Ohio (k)
Felsenthal, G. & Sons, Ill (k)
Fibercast Div., Youngstown Sheet & Tube Co., Okla (l)
Flexfirm Products, Calif (k)
Fluorocarbon Co., Calif (l)
Formica Corp., Sub. of American Cyanamid Co., Ohio (l)
Foss Mfg. Co., Id (l)
Franklin Glue Co., Ohio (k)
Fry Plastics International, Calif (k,l)
Fuller, H.B. Co., Minn (k,l,m)
Furane Plastics, Inc., Calif (l)
General Electric Co., Silicone Products Dept., NY (k,l)
General Mills, Inc., Chemical Div., Ill (k,l)
General Plastics Mfg. Co., Wash (k,l, m)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Goodyear Tire & Rubber Co., Chemical Div., Ohio (k)
Great Lakes Carbon Corp., NY (l)
G. S. Plastics Co., Ohio (k,l,m)
Hadley Bros.-Uhl Co., Mo (m)
Hardman, H.V. Co., Inc., NJ (l)
Haskelite Mfg. Corp., Mich (k,l,m)
Haveg Industries, Inc., Del (l)
Hayes Adhesive Co., Inc., Mo (k,l)
Hiller Aircraft Corp., Adhesive Engineering Div., Calif (l)
Hughes Glue Co., Mich (k,l,m)
Hughson Chemical Co., Div. of Lord Mfg. Co., Pa (k,l,m)
Hysol Corp., NY
(k,l,m)—Ad p 274
Industrial Polychemical Service, Calif (k,l,m)
Interchemical Corp., NY
(k,l,m)—Ad p 469
Interchemical Corp., Finishes Div., NJ (k,l)
Jamestown Finishes, NY (k)
Johns-Manville Corp., NY (k,l,m)
Johns-Manville Corp., Dutch Brand Div., Ill (m)
Kendall Co., Polyken Div., Ill (k,l)
Lee Rubber & Tire Corp., Pa (m)
Leffingwell Chemical Co., Calif (l)
Maas & Waldstein Co., NJ (k,l)
Magic Chemical Co., Mass (k)
Magic Iron Cement Co., Inc., Ohio (k)
Maloney, F.H. Co., Tex (k,l,m)
Manhattan Adhesives Corp., NY (k,l, m)
Mansol Ceramics Co., NJ (l)
Marblette Corp., NY (l)
Marbon Chemical Div., Borg-Warner Corp., Ind (k,l)
Mesa Plastics Co., Calif (l)
Midland Adhesive & Chemical Corp., Mich (k,l,m)
Minnesota Mining & Mfg. Co., Adhesives, Coatings & Sealers Div., Mich
(k,l,m)—Ad p 466
Miracle Adhesives Corp., NY (k,m)
Monsanto Chemical Co., Plastics Div., Mass (l)
Morningstar-Paisley, Inc., NY (k,l,m)
Mystik Adhesive Products, Inc., Ill (l,m)
Narmco Industries, Inc., Narmco Materials Div., Calif (l,m)
National Casein Co., Ill (k,l)
National Starch & Chemical Corp., Structural Products Div., NY (k,l, m)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (k,l,m)
Nukem Products Corp., NY (k)
Ohio Adhesives Corp., Ohio (k,l,m)
Parker Paint Mfg. Corp., Ind (k)
Pawling Rubber Corp., NY (k,l)
Pecora, Inc., Pa (k,m)
Permacel, NJ (k,l,m)
Permaspray Mfg. Co., Tex (l)
Perry-Austen Mfg. Co., NY (l,m)
Peterson, D.J. Co., Wis (k)
Pierce & Stevens Chemical Corp., NY (k,l,m)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (k,l,m)
Plast-Ad Mfg. Co., Ind (k,l)
Poly Resins, Calif (l)
Polymer Chemical Co., Ohio (k,l,m)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa (k)
Polymer Industries, Inc., Conn (k,l,m)
Presstite Div., American-Marietta Co., Mo (k,l,m)
Quelcor, Inc., Pa (l)
Radiation Applications, Inc., NY (k, l,m
Randolph Products Co., NJ (k,l,m)
Raybestos - Manhattan, Inc., Adhesives Div., Conn
(k,l,m)—Ad p 462
Reichhold Chemicals, Inc., NY (k,l)
Ren Plastics, Inc., Mich (l)
Reynolds Aluminum Supply Co., Ga (k,l)
Riverside Plastics Corp., NY (l)
Rohm & Haas Co., Pa (k,l)
Rosco Laboratories, NY (k)
Royston Laboratories, Inc., Pa (k,l,m)
Rubber & Asbestos Corp., NJ (k,l,m)
Rubber Latex Co. of America, NJ
(k,l,m)—Ad p 468
Rubber & Plastics Compound Co., Inc., NY (k)
St. Clair Rubber Co., Mich (m)
Sauereisen Cements Co., Pa (k,l)
Schramm Fiberglass Products, Inc., Ill (l)
Schwartz Chemical Co., Inc., NY (k, l,m)
Shell Chemical Co., NY (l)
Sillcocks Miller Co., NJ (k)
Snyder Mfg. Co., Inc., Ohic (k)
Southern Adhesives Corp., Va (k,l,m)
Standard Insulation Co., NJ (l)
Steelcote Mfg. Co., Mo (l)
Stockwell Rubber Co., Inc., Pa (m)
Superior Plastics, Inc., Ill (k)
Surprenant Mfg. Co., Mass (k)
Swedlow, Inc., Calif (l)
Swift & Co., Adhesives Dept., Ill (k,m)
Synco Resins, Inc., Conn (k,l)
Thermon Manufacturing Co., Tex (k,l)
Toyad Corp., Pa (m)
U S S Chemical Corp., Mass (k,l,m)
Union Paste Co., Mass (k,l,m)
United Shoe Machinery Corp., Mass (k,l,m)
U.S. Rubber Co., Ind (k,l,m)
U.S. Stoneware Co., Ohio (k,l)
Waldman, Joseph & Sons, Epoxy Products Div., NJ
(l)—Ad p 460
Waterman Industries, Inc., Calif (k,l)
Western Plastics Corp., Wash (k)
Westlake Plastics Co., Pa (k)
Williamson Adhesives, Inc., Ill (k,l,m)
Xylos Div., Firestone Tire & Rubber Co., Ohio (k,m)

Alkyd Plastics

Adhesive Products Corp., NY (x)
Allied Chemical Corp., Plastics Div., NY
(p,y)—Ad pp 257-260
American Cyanamid Co., Plastics & Resins Div., NY (p)
Anderson Assoc., Inc., Ohio (y)
Archer-Daniels-Midland Co., Minn (p)
Booty Resineers Div., American-Marietta Co., Ohio (p)
De Soto Chemical Coatings, Inc., Ill (p)
Dyna-Therm Chemical Corp., Calif (p)
Electrofilm, Inc., Calif (t)
Fiber Glass Industries, Inc., NY (a,x, y,cc)
Foss Mfg. Co., Id (cc)
Freeman Chemical Corp., Wis (p)
General Electric Co., Insulating Materials Dept., NY (p)
Glaskyd, Inc., Ohio (y)
Hays Mfg. Co., Pa (y)
Hercules Powder Co., Inc., Del (p)
Jones-Dabney Co., Div. of Devoe & Raynolds Co., Inc., Ky (p)
Kurz Kasch, Inc., Ohio (y)
Mesa Plastics Co., Calif
(p,y,bb,cc)—Ad p 268
Panelyte Div., St. Regis Paper Co., NJ (x,y)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Reichhold Chemicals, Inc., NY (p)
Schenectady Varnish Co., Inc., NY (p)
Sherwin-Williams Co., Ohio (p)
Specialty Resins Co., Calif (p)
U.S. Polymeric Chemicals, Inc., Conn (y)
Westinghouse Electric Corp., Micarta Div., SC (p)

Alloy Steels

(see Steel)

Alumina

(see Ceramics)

Aluminides

(see Refractories)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Aluminized Metals
(see Precoated Metals)

Aluminizing
(see Immersion Coatings)

Aluminum and Its Alloys
Acme Tube, Inc., NJ (ee)
Adams Engineering Co., Inc., Fla (q, ee)
Advance Screw Products Co., Inc., Wis (o)
Advance Stamping Co., Mich (dd)
Aerolite Extrusion Co., Ohio (n,o,bb, dd,ee)
Alabama Wire Co., Inc., Ala (ff)
Albert Pipe Supply Co., Inc., NY (ee)
Alcasco Foundry, Ill (w)
Alloys & Chemicals Corp., Ohio (w, aa)
All-State Welding Alloys Co., Inc., NY (ff)
Alofs Mfg. Co., Mich (cc,dd,ff)
Alpha Metals, Inc., NJ (v)
Aluminium Ltd. Sales, Inc., NY (q,w)
Aluminum Co. of America, Pa (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Aluminum Billets, Inc., Ohio (q)
Aluminum Foils Co., Tenn (v)
American Nickel Alloy Mfg. Corp., NY (w,aa)
American Silver Co., NY (v,dd,ee,ff)
American Smelting & Refining Co., NY (w)
Anaconda Aluminum Co., Ky (o,q,v,w, z,bb,cc,dd,ee)
Apex Smelting Co., Ill (o,q,w,bb)
Arcos Corp., Pa (ff)
Armet Alloys, Inc., Ohio (w)
Arrow Metal Products Corp., NJ (cc)
Atlantic Powdered Metals, Inc., NY (aa)
Atlantic Steel Co., Ga (o,cc)
Auld, D.L. Co., Ohio (o,bb,cc,dd,ff)
Aurora Refining Co., Ill (w)
Babson Dow Mfg. Co., Mass (o)
Badger Aluminum Extrusions, NY (o, q,dd,ee)
Baer Bros. Bronze Powder Co., Inc., Mass (aa)
Bay State Refining Co., Inc., Mass (w)
Belmont Smelting & Refining Works, Inc., NY (n,w,aa)
Biddle Screw Products Co., Ind (o, bb,ee)
Bohn Aluminum & Brass Corp., Mich (o,q,bb,ee)
Bonnell, William L. Co., Inc., Ga (bb,ee)
Both, O.A. Corp., Mass (aa)
Bridgeport Brass Co., Conn (o,bb,cc, dd,ff)
Bridgeport Rolling Mills Co., Conn (dd)
Briel Industries, Inc., Ky (q,w)
Brinkerhoff Brass & Bronze Works, Inc., NY (z,bb,cc,dd,ee)
Bunting Brass & Bronze Co., Ohio (o)
Caspers Tin Plate Co., Ill (cc,dd)
Castle, A.M. & Co., Ill (o,z,bb,cc,dd, ee,ff)
Central Fabricators, Inc., Ohio (z,bb, cc,ee)
Central Steel & Wire Co., Ill (o,z, bb,cc,dd,ee,ff)
Channel Master Corp., NY (q,ee)
Chase Brass & Copper Co., Inc., Sub. of Kennecott Copper Corp., Conn (o,z,bb,cc,dd,ee,ff)
Clark Perforating Co., Mich (cc,dd)
Clarksville Foundry & Machine Works, Tenn (o,w,z,ee)
Cleveland Electro Metals Co., Ohio (w)
Commercialores, Inc., SC (aa)
Copper & Brass Sales, Inc., Mich (o, z,bb,dd,ee,ff)
Corson Industries, Pa (q,bb,ee)
Craft Metal Spinning Co., Ill (cc)
Crescent Bronze Powder Co., Ill (aa)
Designers Metal Corp., Ill (cc)
Dixie Aluminum Corp., Ga (o,q,bb,ee)
Dormont Mfg. Co., Pa (ee)
Dow Chemical Co., Mich (z,cc,ee)
Ductile Iron Foundry, Inc., Conn
Dudek & Bock Spring Mfg. Co., Ill (ff)
Eastern Rolling Mills, Inc., NY (cc,dd)
Edgcomb Steel & Aluminum Corp., NJ (o,z,cc,dd,ee)
Empire Metal Co., NY (o,q,w)
Essex Industrial Products Div., Essex Wire Corp., Ind (ff)
Essex Wire Corp., Magnet Wire Div., Ind (ff)
Eynon-Dakin Co., Mich (ee)
Fairmont Aluminum Co., W. Va
(cc,dd)—Ad p 151
F. A. Pilgrim Co., Ohio (o,bb,ee)
Federated Metals Div., American Smelting and Refining Co., NY
(w)—Ad p 156
Flynn, Michael Mfg. Co., Pa (o,bb,ee)
Foamalum Corp., Ill (foamed)
Foil Div., Reynolds Metals Co., Va (v)
Frasse, Peter A. & Co., Inc., NY (o,z,bb,cc,dd,ee,ff)
Fromson Orban Co., Inc., NY (o,z, bb,cc,dd,ee,ff)
Frontier Bronze Corp., NY
(w)—Ad p 166
General Cable Corp., NY (ff)
General Extrusions, Inc., Ohio (o,bb, ee)
General Motors Corp., Central Foundry Div., Mich
General Smelting Co., Pa (w)
Glidden Co., Metals Dept., Pa (aa)
Gold Leaf & Metallic Powders, Inc., NY (aa)
Harbot Die Casting Corp., NJ (w)
Hardy, Charles, Inc., NY (aa)
Harris, Benjamin & Co., Ill (w)
Harvey Aluminum, Calif (o,q,w,bb,ee)
Hayden Wire Works, Inc., Mass (aa)
Haydon Corp., NY (ee)
Hexcel Products, Inc., Calif (v)
Himmel Bros. Co., Conn (o)
Hommel, O. Co., Pa (aa)
Horton-Angell Co., Mass (ee,ff)
Houston Blow Pipe & Sheet Metal Works, Tex (o,z,cc)
Hunter Engineering Co., Calif (o,bb, cc,dd,ee)
Industrial Foil Div., Aluminum Co. of America, Pa (foil)
Inshield Die & Stamping Co., Ohio (cc,dd)
Jackson Steel Products, Inc., NY (ee)
Jarl Extrusions, Inc., NY (o,q,bb,ee)
Jelliff, C.O. Mfg. Corp., Conn (ff)
Jobbins, William F., Inc., Ill (w)
Johnston Foil Div., Standard Packaging Corp., Mo (v,cc)
Kaiser Aluminum & Chemical Sales, Inc., Ill (n,o,q,v,w,z,bb,cc,dd,ee,ff)
Kawecki Chemical Co., NY (w)
Kawneer Co., Mich (o,q,z)
Kinkead Industries, Inc., Ill (q,z,cc, dd)
Kirk, Morris P. & Son, Calif (w)
Korhumel Steel & Aluminum Co., Ill (o,z,bb,cc,dd,ee,ff)
Laminated Shim Co., Conn (cc)
Langsenkamp, F.H. Co., Ind (o,z,bb, cc,dd,ee,ff)
Light Metals, Inc., Ind (n)
Lockhart Iron & Steel Co., Pa (o, z,bb,cc,dd,ee)
Lucas-Milhaupt Engineering Co., Wis (dd,ff)
Lundquist Tool & Mfg. Co., Inc., Mass (cc,dd)
Magna Mfg. Co., Inc., NJ (aa)
Magnode Products, Inc., Ohio (o)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass. (o,ee)
Malone Bronze Powder Works, Inc., NY (aa)
May, Inc., Tex (o,q,bb,ee)
McGregor-Michigan Corp., Mich (ee)
Meier Brass & Aluminum Co., Mich (o,z,bb,cc,dd,ee,ff)
Metal Goods Corp., Mo (o,z,bb,cc,dd, ee,ff)
Metallizing Co. of Los Angeles, Inc., Calif (bb,ff)
Metals Disintegrating Co. Div., American-Marietta Co., NJ (aa)
Metco, Inc., NY (ff)
Morrisville Foundry Co., Inc., Vt (bb)
Mueller Brass Co., Mich
(bb)—Ad p 404
Murray, A.B. Co., Inc., NJ (ee)
National Aluminum Co., Ohio (bb,ee)
National Lead Co., NY (o,bb,ee)
National U.S. Radiator Corp., Plastic Metals Div., NY (aa)
Navan Products, Inc., Sub. of North American Aviation, Inc., Calif (w)
Nesor Alloy Products Co., NJ (ff)
New Jersey Aluminum Extrusion Co., Inc., NJ (bb,ee)
New Jersey Metals Co., NJ (w)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Nuclear Metals, Inc., Mass (bb,dd,ee)
Olds Alloys Co., Calif (ee)
Olin Mathieson Chemical Corp., Metals Div., NY (o,q,w,z,bb,cc,dd,ee,ff)
Ormond Mfg. Co., Inc., NJ (dd,ff)
Penn Brass & Copper Co., Pa (ee)
Pioneer Aluminum, Inc., Calif (o,z,bb, cc,ee)
Pfister Tubing Corp., NJ (ee)
Plasmadyne Corp., Calif (aa)
Plasmatech Div., Valley Metallurgical Processing Co., Conn (aa)
Precision Tube Co., Inc., Pa (ee)
Purdy, A. R. Co. Inc., NJ (o,z,bb,cc, dd,ee,ff)
Quaker State Metals Co., Pa (cc,ee)
Rathbone Corp., Mass (bb)
Reade Mfg. Co., Inc., NJ (aa)
Republic Foil, Inc., Conn (v)
Republic Metals Co., Inc., NY (o,v, w)
Republic Supply Co. of California (o, z,bb,cc,ee,ff)
Revere Copper & Brass, Inc., NY (o,q, v,w,z,bb,cc,dd,ee)
Reynolds Aluminum Supply Co., Ga (o, z,bb,cc,dd,ee,ff)
Reynolds Metals Co., Va (o,q,v,w,z,aa, bb,cc,dd,ee,ff)
Rigidized Metals Corp., NY (cc,dd)
Rodney Metals, Inc., Mass (v,dd)
Roebling's, John A. Sons Div., Colorado Fuel & Iron Corp., NJ (dd,ff)
Ryerson, Joseph T. & Son, Inc., Ill (o,q,z,bb,cc,dd,ee,ff)
Saginaw Bearing Co., Mich (o)
Sall, George Metals Co., Inc., Pa (w)
Saramar Aluminum Co., Ohio (o,bb,ee)
Scovill Mfg. Co., Mill Products Div., Conn
(bb,cc,dd)—Ad p 165
Security Sash & Screen Co., Mich (cc)
Sel-Rex Corp., NJ
Sherwatt Equipment & Mfg. Co., Inc., NY (ff)
Simoniz Products Div., Simoniz Co., Ill (cc)
Smith-Moon Steel Co., Inc., Kan (o,z,cc)
Sonken-Galamba Corp., Kan (q,w)
Southern Aluminum Finishing Co., Inc., Ga (o,z,bb,cc,dd,ee)
Standard Metals Corp., Mass (ee)
Stranahan Foil Co., Inc., NJ (v)
Sun Steel Co., Ill (cc,dd)
Techalloy Co., Inc., Pa (n,dd)
Texas Instruments, Inc., Metals & Controls Div., Mass (v)
Trim Alloys, Inc., Mass (o,bb,ee)
Ullmann, Inc., Wis (o,ee)
United Screw & Bolt Corp., Ill (bb, cc,dd,ff)
United Smelting & Aluminum Co., Inc., Conn (cc,dd)
U.S. Bronze Powders, Inc., NJ (aa)
U.S. Extrusions Corp., NY (bb)
U.S. Gasket & Shim Co., Ohio (v)
U.S. Reduction Co., Ind (w)
United Wire & Supply Corp., RI (ee, ff)
Universal Converting Corp., Mass (o, bb,ee)
Utility Mfg. Co., Mass (bb)
Vanadium Corp. of America, NY (w)
Vulcan Rail & Construction Co., NY (o,z,ee)
Warner Mfg. Corp., NJ (o,bb,ee)
Waterman Industries, Inc., Calif (o,bb, cc,dd,ee)
Wells Aluminum Corp., Ind (o,bb,ee)
Werner, R.D. Co., Pa (o,q,w,bb,ee)
White Metal Rolling & Stamping Corp., NY (o,q,bb,ee,ff)
Whitehead Metal Products Co., Inc., NY (o,w,z,bb,cc,dd,ee,ff)
Wilder Mfg. Co., Inc., Calif (o,cc)
Wilson-Hurd Mfg. Co., Inc., Wis (cc)
Wolverine Tube Div., Calumet & Hecla, Inc., Mich
(ee)—Ad p 403
Wright, Albert Screw Machine Products, Calif (bb)

Aluminum Bronze
(see Copper)

Anodes
(see specific metal)

Anodic Coatings
(see Conversion Coatings)

Asbestos
American Asbestos Textile Corp., Pa (r,s)
American Brakeblok Div., American Brake Shoe Co., Mich (r)
American Smelting & Refining Co., NY (s)
Asbestos Corp. of America, NJ (r,s)
Asbestos Textile Co., Inc., Ill (r,s,cc)
California Metal Enameling Co., Calif (r)
Carey, Philip Mfg. Co., Ohio (r,s,cc)
Carolina Asbestos Co., NC (r)
Chicago Gasket Co., Ill (cc)
Cleveland Container Co., Ohio (ee)
Connell Asbestos Mfg. Co., NY (r)
Dumont Corp., Calif (r,z,cc,ee)
Firestone Tire & Rubber Co., World Bestos Div., Ind (r,cc)
Garlock Packing Co., NY (r,s,cc,ee)
Gatke Corp., Ill (r)
General Asbestos Gasket Mfg. Corp., Mo (r)
General Gasket, Inc., Conn (r)
Hall, C. P. Co., Ohio (s)
Insulation Mfrs. Corp., Ill (ee)
Johns-Manville Corp., NY (r,s,aa,cc,ee)
Keasbey & Mattison Co., Pa (s,cc,ee)
Lake Asbestos of Quebec, Ltd., Sub of American Smelting & Refining Co., NY
(s)—Ad p 305
Mica Fabricating Co., NJ (s)
National Gasket & Washer Mfg. Co., Inc., NY (r,cc)
Nicolet Industries, Inc., NY (r,s,cc,ee)
North American Asbestos Corp., Ill (r,s)
Panelyte Div., St. Regis Paper Co., NJ (bb,cc)
Peerless Products Industries, Ill (r)
Philadelphia Asbestos Corp., Pa (r)
Precision Paper Tube Co., Ill (ee)
Prince Rubber & Plastics Co., Inc., NY (cc,dd)
Raybestos-Manhattan, Inc., NJ (bb,cc)
Raybestos-Manhattan, Inc., Raybestos Div., Conn (r)
Riegel Paper Corp., NY (r)
Rogers Corp., Conn (cc)
Rostone Corp., Ind (r)
Ruberoid Co., NY (s)
Russell Mfg. Co., Conn (r,s)
Smith Chemical & Color Co., Inc., NY (aa)
Southern Asbestos Co., NC (r,s,ee)
Standard Asbestos Mfg. Co., Ill (r,s)
Staver Co., Inc., NY (r,cc)
Stone Paper Tube Div., Stone Straw Corp., Washington, DC (ee)
Superior Mfg. Co., Pa (r)

Union Asbestos & Rubber Co., Ill (r, ee,ee)
U.S. Polymeric Chemicals, Inc., Conn (s)
U.S. Rubber Co., NY (s)
Vellumoid Co., Mass (r,cc)
Victor Mfg. & Gasket Co., Ill (r,cc)
Wisconsin Gasket & Mfg. Co., Wis (cc)

Balsa Wood
(see Wood)

Bar
(see specific metal)

Beryllium
Advance Stamping Co., Mich (dd)
American Silver Co., Inc., NY (v,dd)
Babcon Dow Mfg. Co., Mass (o)
Belmont Smelting & Refining Works, Inc., NY (o,aa)
Beryllium Corp., Pa
(o,q,w,aa,bb)—Ad p 159
Brinkerhoff Brass & Bronze Works, Inc., NY (dd)
Brooks & Perkins, Inc., Mich
Brush Beryllium Co., Ohio (o,q,v,w,z, aa,bb,cc,dd,ee,ff)
Craft Metal Spinning Co., Ill (cc)
Dudek & Bock Spring Mfg. Co., Ill (ff)
General Astrometals Corp., NY (o,q, v,w,z,aa,bb,cc,dd,ee,ff)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (ff)
Inshield Die & Stamping Co., Ohio (dd)
Instrument Specialties Co., Inc., NJ (bb,dd,ff)
Lundquist Tool & Mfg. Co., Inc., Mass (cc,dd)
Makepeace, D. E. Div., Engelhard Industries, Inc., Mass (dd,ff)
Mallory, P. R. & Co., Inc., Ind (bb dd)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb)
Nuclear Metals, Inc., Mass (w,bb,cc, dd,ee,ff)
Olds Alloys Co., Calif (ee)
Plasmadyne Corp., Calif (aa)
Riverside-Alloy Metal Div., H. K. Porter Co., Inc., NJ (bb,ff)
Rodney Metals, Inc., Mass (v,dd)
Sel-Rex Corp., NJ (n)
Seymour Mfg. Co., Conn (bb)
Superior Tube Co., Pa (ee)
Texas Instruments, Inc., Metals & Controls Div., Mass (v)
Vitro Chemical Co., NY

Beryllium Copper
(see Copper)

Billets
(see specific metal)

Bismuth and Its Alloys
Alpha Metals, Inc., NJ (o,q,v,bb,cc,dd)
American Metal Climax, Inc., NY (o,w,aa)
Anaconda Co., NY (o)
Belmont Smelting & Refining Works Inc., NY (n,o,q,w,aa)
Cerro Sales Corp., Sub. of Cerro Corp., NY
(w)—Ad p 154
Division Lead Co., Ill (o,ff)
Empire Metal Co., NY (n,o,q,w,bb,ff)
Federated Metals Div., American Smelting & Refining Co., NY (o,w)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (aa)
Langsenkamp, F. H. Co., Ind (q)
Metals Disintegrating Co. Div., American-Marietta Co., NJ (aa)
Peerless Alloy Co., Colo (o,w)
Republic Metals Co., Inc., NY (o,w)
River Smelting & Refining Co., Ohio (o)
Sel-Rex Corp., NJ (n)
United Refining & Smelting Co., Ill (n,o,q,w,z,bb,cc,dd,ff)
U.S. Smelting, Refining & Mining Co., NY (w,dd)

Borides
(see Refractories)

Brass
(see Copper)

Brazing Alloys
Abalon Precision Mfg. Corp., NY
All-State Welding Alloys Co., Inc., NY
Alofs Mfg. Co., Mich
Aluminum Co. of America, Pa
American Platinum & Silver Div., Engelhard Industries, Inc., NY
American Products Corp., Ill
American Silver Co., NY
Ampco Metal, Inc., Wis
Belmont Smelting & Refining Works, Inc., NY
Bridgeport Brass Co., Conn
Burgess-Norton Mfg. Co., Ill
Coast Metals, Inc., NJ
Composite Industrial Metals, Inc., RI
Dana Corp., Auburn Div., Ind
Dormont Mfg. Co., Pa
Electric Materials Co., Pa
Eutectic Welding Alloys Corp., NY
Fabriform Metal Brazing, Calif
Falstrom Co., NJ
Farrelloy Co., Pa
General Findings & Supply Co., Industrial Div., Mass
Glidden Co., Ind
Glidden Co., Chemical Divs., Metals Dept., Ind
Goldsmith Bros. Div., National Lead Co., Ill
Hamilton Die Cast, Inc., Ohio
Handy & Harman, NY
—Ad p 467
Hayden Wire Works, Inc., Mass
Haynes Stellite Co., Div. of Union Carbide Corp., NY
Hunter Corp., Pa
Huntington Alloy Products Div., International Nickel Co., Inc., W. Va
Inland Mfg. Co., Neb
Jervis Corp., Mich
Kenmore Machine Products, Inc., NY
Kinkead Industries, Inc., Ill
Kling Metal Spinning & Stamping Co., NY
Kwikset Powdered Metal Products, Calif
Lucas - Milhaupt Engineering Co., Wis
—Ad p 468
Machine Products Corp., Ohio
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass.
Mansol Ceramics Co., NJ
Marquette Mfg. Co. Div., Marquette Corp., Minn
McDowell Mfg. Co., Pa
Metal Goods Corp., Mo
Nuclear Materials & Equipment Corp., Pa
Revere Copper & Brass, Inc., NY
Rockwell Engineering Co., Ill
Solar Aircraft Co., Calif
Trenton Pipe Nipple Co., NJ
United Wire & Supply Corp., RI
Uniworld Research Corp. of America, Ohio
Vanadium-Alloys Steel Co., Pa
Victor Equipment Co., Calif
Wall Colmonoy Corp., Mich
Waterman Industries, Inc., Calif
West Haven Foundry Co., Conn
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif
Whitehead Metal Products Co., Inc., NY
Williams Gold Refining Co., Inc., NY

Bronze
(see Copper)

Buna N Rubber
(see Acrylonitrile-Butadiene Rubber)

Butadiene Styrene
(see Styrene Butadiene)

Butyl Rubber
(see Isoprene-Isobutylene Rubber)

Butyrate
(see Cellulose Acetate Butyrate)

Cadmium
Allied Research Products, Inc., Md (n)
Alpha Metals, Inc., NJ (o,q,v,bb,cc,dd)
American Metal Climax, Inc., NY (n,o,w,aa,bb)
American Silver Co., NY (v,dd)
American Smelting & Refining Co., NY (n,q,w)
American Zinc Sales Co., Mo (n,o,z)
Anaconda Co., NY (o)
Anchor Metal Co., Inc., NY (w)
Auld, D.L. Co., Ohio (n)
Belmont Smelting & Refining Works, Inc., NY (n,o,v,w,z,aa,cc,ff)
Bunker Hill Co., Calif (n,o)
Cerro Sales Corp., Sub. of Cerro Corp., NY
(z,bb)—Ad p 154
Division Lead Co., Ill (v,cc)
Eagle-Picher Co., Ohio (q)
Empire Metal Co., NY (n,o,q,w,bb,ff)
Federated Metals Div., American Smelting & Refining Co., NY (n,o,w)
Goldsmith Bros. Div., National Lead Co., Ill (o,w)
Hamilton Watch Co., Precision Metals Div., Pa (v,cc,dd)
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (ff)
Hull, R.O. & Co., Inc., Ohio (n)
International Minerals and Metals Corp., NY (w)
Lucas-Milhaupt Engineering Co., Wis (dd,ff)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (ee)
McGean Chemical Co., Ohio (n,dd)
Metals Disintegrating Co. Div., American-Marietta Co., NJ (aa)
Modern Plating Corp., Ill (n)
New Jersey Metals Co., NJ (n)
New Jersey Zinc Co., NY (n)
Octagon Process, Inc., NY (n,o,q,w,z, bb,cc,dd)
Peerless Alloy Co., Colo (o,w)
Republic Metals Co., Inc., NY (n,o,w)
River Smelting & Refining Co., Ohio (w)
St. Joseph Lead Co., NY (n,o,w)
Sel-Rex Corp., NJ (n)
Stevens, Frederic B., Inc., Mich (n)
Triangle Conduit & Cable Co., Inc., NJ (ff)
Udylite Corp., Mich (n)
United Refining & Smelting Co., Ill (n,o,q,w,z,bb,cc,dd,ff)
U.S. Smelting, Refining & Mining Co., NY (o,w,bb)

Calorized Coatings
(see Diffusion Coatings)

Carbides
(see Cermets, Refractories and specific metal)

Carbon, Graphite
American Metal Products Co., Mich (bb,cc,dd,ee)
Becker Bros. Carbon Co., Ill (r,z,aa, bb,cc,ee)
Black Bear Co., Inc., NY (aa)
Blaco Mfg. Co., Ohio (aa)
Carbone Corp., NJ (r)
Dixon, Joseph Crucible Co., NJ (z, aa,bb)
Electro Chemical Engineering & Mfg. Co., Pa (r)
General Astrometals Corp., NY (r,z, bb,cc,ee)
General Electric Co., Chemical & Metallurgical Div., Ill (diamond)
Gibson Electric Sales Corp., Pa (r,aa)
Graphite Metallizing Corp., NY (r)
Graphite Products Corp., Ohio (aa)
Graphite Specialties Corp., NY
(r,bb,ee)—Ad p 314
Great Lakes Carbon Corp., NY
(r,z,bb)—Ad p 308
Heil Process Equipment Corp., Ohio (r)
Henrite Products Corp., Ohio (r)
Hofford Varnish Co., Inc., NJ (r)
Illinois Zinc Co., Div. of Hydrometals, Inc., Ill (z,cc,dd)
Markal Co., Ill (z)
McGee Chemical Co., Inc., Pa (aa)
Metallized Carbon Co., NY (r)
Morganite, Inc., NY (r,bb,ee)
National Carbon Co., Div. of Union Carbide Corp., NY
(r,s,z,aa,bb,ee)—Ad p 306

KEY

MATERIALS

n—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Ohio Carbon Co., Ohio
(r,z,aa,bb,cc,ee)—Ad p 318
Pure Carbon Co., Inc., Pa
(bb)—Ad p 304
Russell Mfg. Co., Conn (r,s)
St. Marys Carbon Co., Pa (r,z)
Servwell Products Co., Ohio (aa)
Smith Chemical & Color Co., Inc., NY (aa)
Speer Carbon Co., Pa
(r)—Ad p 316
Stackpole Carbon Co., Pa (r,z,bb,ee)
Superior Carbon Products, Inc., Ohio (r)
Thermon Manufacturing Co., Tex (r, aa)
Thompson, H. I. Fiber Glass Co., Calif (s)
United Carbon Products Co., Mich (r, z,aa,bb,cc,ee)
U.S. Graphite Co., Div. of Wickes Corp., Mich (r)
U.S. Polymeric Chemicals, Inc., Conn (s)

Carbon Steel

(see Steel)

Casting Resins

(see specific plastic or rubber)

Castings, Centrifugal

Alcasco Foundry, Ill (b)
All Metals Precision Casting Corp., NY (a,b,g)
Allegheny Ludlum Steel Corp., Pa (g)
Alloy Precision Castings Co., Ohio (a, b,c,e,f)
American Brake Shoe Co., NY (a,b,j)
American Cast Iron Pipe Co., Ala
(a,c,f,g)—Ad p 398
American Crucible Products Co., Ohio (h)
Ampco Metal, Inc., Wis (b)
Asco Sintering Corp., Calif (a,b)
Baldwin-Lima-Hamilton Corp., Pa (a, b,f)
Bendix Foundries Div., Bendix Aviation Corp., NJ (a,e)
Blaw-Knox Co., Pa (f,g)
Buckeye Brass & Mfg. Co., Ohio (a)
Bunting Brass & Bronze Co., Ohio (b)
Calorizing Co., Pa (f,g)
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich (c,g)
Centrifugal Casting Co., Calif (c,f,g)
Centrifugal Casting Co., NY (a,b,e,f, h,j)
Centrifugal Casting Machine Co., Okla (a,b)
Centr-O-Cast & Engineering Co., Mich (a)
Coast Metals, Inc., NJ (c,f)
Comet Metal Products Co., Inc., NY (d)
Cooper Alloy Corp., NJ (g)
Copper & Brass Sales Inc., Mich (b)
Curtiss-Wright Corp., Metal Processing Div., NY (g)
Cyril Bath Co., Ohio (g)
Dayton Foundry, Calif (c)
Derby Castings Co., Conn (a,b)
Division Lead Co., Ill (d)
Duraloy Co., Pa
(f,g)—Ad p 429
Electro-Alloys Div., American Brake Shoe Co., Ohio (g)
Engineered Castings Div., American Brake Shoe Co., NY (c,g)
Esco Corp., Ore (f,g,h)
Florence Pipe Foundry & Machine Co., NJ (c)
Frasse, Peter A. & Co., Inc., NY (g)
General Alloys Co., Mass (f)
General Electric Co., Foundry Dept., NY (a,b)
Haynes Stellite Co., Div. of Union Carbide Corp., NY (f)
Hi-Grade Alloy Corp., Ill (d,j)
Hughes Tool Co., Tex (g)
Humphrey Castings, Inc., Calif (a,b,f, g)
Huntington Alloy Products Div., International Nickel Co., Inc., W.Va (f)
Illinois Precise Casting Co., Ill (a, b,f,g)
Janney Cylinder Co., Pa (a,b,c,f)
Johnson Bronze Co., Pa (b)
Kay-Brunner Steel Products, Inc., Calif (g)
Kelsey-Hayes Co., Metals Div., NY (f)
Lebanon Steel Foundry, Pa (g)
Linton Precision Casting Co., Ind (a, b,c,f,g,j)
Lumen Bearing Co., NY (b)
Magnolia Metal Co., NJ (b)
Mallory, P.R. & Co., Inc., Ind (b)
McCarter Iron Works, Inc., Pa (c,g)
Meehanite Metal Corp., NY
(c)—Ad p 431
Meier Brass & Aluminum Co., Mich (b)
Metal Goods Corp., Mo (a,b,f)
Metals Processing Div., Curtiss-Wright Corp., NY (f,g)
Milwaukee Aluminum & Brass Foundry, Wis (a,b)
Misco Precision Casting Co., Mich (c, f,g)
Moccasin Bushing Co., Tenn (b)
National Bearing Div., American Brake Shoe Co., Pa (b)
National Lead Co., NY (b,d)
National Lead Construction Co., Inc., Pa
Ohio Steel Foundry Co., Ohio (f)
Oil City Iron Works, Tex (c)
Olds Alloy Co., Calif (a,b,d,f)
Oregon Metallurgical Corp., Ore (h)
Perfect Circle Corp., Ind (c)
Precision Castparts Corp., Ore (b,f,g)
Precision Founders, Inc., Calif (a,b,c,f, g,j)
Precision Metalsmiths, Inc., Ohio (a, b,c,d,f,g)
Quality Electric Steel Castings, Inc., Tex (g)
Rockwell Engineering Co., Ill (a,b,c,g)
Saginaw Bay Industries, Inc., Mich (a,e)
Sandusky Foundry & Machine Co., Ohio
(b,f,g)—Ad p 427
Schilling Bronze Co., NY (b,d,f,j)
Sheller Mfg. Corp., Mich (j)
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio (b,c,f)
Sorbo-Mat Process Engineers, Mo (c)
State Foundry & Machine Co., Wis (c)
Staver Co., Inc., NY (d)
Terre Haute Bronze & Brass Foundry, Ind (b)
Thys Co., Calif (a,b,c,f,g)
True Alloys, Inc., Mich (a,b,d,j)
U.S. Pipe & Foundry Co., Ala (c,g)
Uniworld Research Corp. of America, Ohio (c)
Utica Drop Forge & Tool Co., NY (f, g)
Vollrath Co., Wis (g)
Weatherhead Co., Ind (j)
West Steel Casting Co., Ohio (f)
Winters Foundry & Machine Co., Inc., Ohio (a,b)
Wisconsin Centrifugal Foundry, Inc., Wis (a,b,d,f,g)

Castings, Die

A & A Die Casting Co., Calif (j)
Able Tool & Engineering Co., Ill (a,j)
Accurate Die Casting Co., Ohio (a,e,j)
Accurate Metal Weather Strip Co., Inc., NY (j)
Admiral Die Castings Div., Portable Electric Tools, Inc., Ill (a,j)
Advance Pressure Castings, Inc., NY (a,j)
Advance Tool & Die Casting Co., Wis (a,j)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (a,j)
Allen-Stevens Corp., NY (j)
Aluminum Co. of America, Pa (a)
Ambrit Industries, Inc., Calif (a,d,j)
American Aluminum Castings Co., NJ (a)
American Foundries Co., Mich (c)
American Foundry & Machine Div., Elmco Corp., Utah (g)
Auel Industries, Pa (j)
Auld, D.L. Co., Ohio (a,j)
Aurora Metal Co., Ill (b)
Badger Die Casting Corp., Wis (a,j)
Belmont Smelting & Refining Works, Inc., NY (a,d,j)
Bendix Foundries Div., Bendix Aviation Corp., NJ (a,e)
Briel Industries, Inc., Ky (a)
Brown Lipe Chapin Div., General Motors Corp., NY (j)
Centrifugal Casting Machine Co., Okla (a)
Centr-O-Cast & Engineering Co., Mich (a)
Century Die Casting Co., Ill (a,j)
Char-Lynn Co., Diecasting Div., Minn (a,j)
Chicago White Metal Casting, Inc., Ill (a,j)
Comet Metal Products Co., Inc., NY (j)
Conneaut Die Casting Co., Ohio (a,j)
Continental Die Casting Corp., Mich (j)
Crown Metal Co., Wis (d)
Davis Products Corp., NY (j)
Dayton Bronze Bearing Co., Ohio (a,j)
Dayton Malleable Iron Co., Ohio (a)
Die Cast Products, Inc., Calif (a,j)
Diecast Corp., Mich (a,j)
Division Lead Co., Ill (d)
Doehler-Jarvis Div., National Lead Co., Ohio, (a,b,e,j)
Dollin Corp., NJ (a,j)
Duane Specialties, Ltd., NJ (j)
Du-Wel Metal Products, Inc., Mich (a,j)
Eclipse-Pioneer Div., Bendix Aviation Corp., NJ (a,c)
Electric Autolite Co., Ohio (a,j)
Evans Metal Co., Ga (a,d,j)
Federal Die Casting Co., Ill (a)
General Electric Co., Foundry Dept., NY (b)
General Motors Corp., Central Foundry Div., Mich (a)
General Motors Corp., Fabricast Div., Ind (a)
Grammes, L.F. & Sons, Inc., Pa (j)
Grand Rapids Brass Co., Mich (j)
Grey, C.M. Industries, Inc., NJ (a,j)
Gries Reproducer Corp., NY (j)
Hamilton Die Cast, Inc., Ohio (a,j)
Hampden Brass & Aluminum Co., Mass (a,j)
Harbot Die Casting Corp., NJ (a)
Hardy Mfg. Corp., Ind (j)
Harvey Aluminum Sales, Inc., Calif (a)
Harvill Corp., Calif (a,b,e,j)
Hercules Fastener Co., Ill (j)
Hilfinger Corp., Ohio (j)
Hoover Co., Die Casting Div., Ohio (a, j)
Humphrey Castings, Inc., Calif (a)
Jersey Plastic & Die Casting Co., NJ (a,j)
Jervis Corp., Mich (a,j)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kamin Die Casting & Mfg. Co., Ill (a,j)
Kent Castings Corp., Mich (j)
Kiowa Corp., Iowa (a,j)
Krone, Paul Die Casting Co., Ill (a,j)
La France Precision Casting Co., Pa (j)
Lake Erie Foundry Co., NY (c)
Latrobe Die Casting Co., Pa (a,d,j)
Lester Castings, Inc., Ohio (a,j)
Light Metals, Inc., Ind (a,e)
Litemetal Dicast, Inc., Mich (e)
Littlestown Hardware & Foundry Co., Inc., Pa (a)
Livingston-Tyler Products, Ohio (j)
Madison Kipp Corp., Wis (a,j)
Magline Inc., Mich (a,e)
Mallory, P.R. & Co., Inc., Ind (b,h)
Manor Die Cast Corp., Ohio (a)
Meehanite Metal Corp., NY
(c)—Ad p 431
Meta-Mold Aluminum Co., Sub. of Dayton Malleable Iron Co., Wis (a,e)
Milwaukee Die Casting Co., Wis (a,d,j)
Missouri Diecasting Co., Mo (a,j)
Mohawk Foundries, Inc., Ohio (a)
Moldcast Products, Inc., NJ (a)
Monarch Aluminum Mfg. Co., Ohio (a,j)
Monarch Tool & Mfg. Co., Ky (j)
Mt. Vernon Die Casting Corp., Conn (a)
National Die Casting Co., Ill (a,j)
National Lead Co., NY (a,b,d,e,j)
National Lead Construction Co., Inc., Pa (d)
National Lock Co., Ill (j)
National Malleable & Steel Castings Co., Ohio (j)
National Supply Div., Armco Steel Corp., Pa (g)
New England Die Casting Co., Conn (a,j)
New Jersey Zinc Co., NY
(j)—Ad pp 406-407
New Products Corp., Mich (a,e,j)
Newton-New Haven Co., Conn (a,j)
Norgren-Stemac, Inc., Colo (j)
Olderman Mfg. Corp., Conn (j)
Paragon Die Casting Co., Ill (a,j)
Paramount Die Casting Co., Mich (a e,j)
Parker White Metal Co., Pa (a,d,f,j)
Peasley Products, Inc., Conn (a,j)
Phoenix Die Casting Co., NY (a,j)
Pittsburgh Die & Casting Co., Pa (a,j)
Pressure Castings, Inc., Ohio (a,j)
Production Die Casting Co., Tex (a,e,j)
Rangers Die Casting Co., Calif (a,j)
Republic Die Casting Div., Landers Frary & Clark, Ark (a,j)
Republic Metals Co., Inc., NY (d)
Rockwell Engineering Co., Ill (a,b,c,g)
Rupert Diecasting Co., Mo (a,j)
Ryerson, Joseph T. & Sons, Inc., Ill (a,g)
Saginaw Bay Industries, Inc., Mich (a,e)
St. Louis Diecasting Corp., Mo (a,j)
St. Marys Foundry Co., Ohio (c)
Sargent & Greenleaf, Inc., NY (a,j)
Schilling Bronze Co., NY (a,b,d,f,j)
Schneider, Bowman Co., Inc., Pa (c)
Schultz Die Casting Co., Ohio (a,j)
Schwarzkopf Development Corp., NY
Sillcocks Miller Co., NJ (a,c,d,j)
Southern Metal Products Co., La (a)
Star Heel Plate Co., Inc., NJ (a,j)
Staver Co., Inc., NY (d)
Stella Products Corp., NJ (j)
Sterling Die Casting Co., NY (a,j)
Stewart-Warner Corp., Stewart Die Casting Div., Ill (a,e,j)
Stoody Co., Calif (a,b,d,e)
Superior Die Casting Co., Ohio (a,j)
Thompson Products, Light Metals Div., Ohio (a)
Titan Metal Mfg. Co. Div., Cerro Corp., Pa (b)
Tower Grove Foundry, Mo (c)
Twin City Die Casting Co., Minn (a,d,j)
Veeder-Root, Inc., Conn (j)
Vulcan Rail & Construction Co., NY (a,c,g)
Weber-Knapp Co., NY (a)
West Irving Die Casting Co., Ill (a)
Westland Die Casting, Inc., Calif (a,j)
Wheaton Die Casting Corp., NJ (a,j)

Castings, Investment

All Metals Precision Casting Corp., NY (a,b,g)
Alloy Precision Castings Co., Ohio (a, b,c,e,f,g)
Arwood Corp., NY (a,b,e,g)
Atlantic Casting Engineering Corp., NJ
(a,b)—Ad p 412
Austenal Co., Div. of Howe Sound Co., NY (a,c,f,g)
Bome Engineering Corp., Calif (a,b,f,g)
Buckeye Brass & Mfg. Co., Ohio (a, b,c,g)
Casting Engineers, Inc., Ill (a,b,c,f,g)
Casting Engineers, NY (a,b,c,e,f,g,h,j)
Centrifugal Casting Co., NY (a,b,e,f, h,j)
Chrysler Corp., Mich (a,b,c,e,f,g,h,j)
Electronicast Div., Nilsen Mfg. Co., Ill (a,b,c,e,f,g,h,j)
Engineered Precision Casting Co., NJ (a,b,c,f,g)
Esco Corp., Ore (h)

General Motors Corp., Fabricast Div., Ind (a,f)
Central Foundry Div., Mich (a)
Gray-Syracuse, Inc., NY (a,b,c,f,g)
Harcast Co., Inc., Pa (a,b,c,f,g)
Haynes Stellite Co., Div. of Union Carbide Corp., NY (c,f,g)
Hawkridge Bros. Co., Mass (a,b,c,e,f,g,h,j)
Hitchiner Mfg. Co., Inc., NH (a,b,c,f,g)
Howard Foundry Co., Ill (a,b,c,f,g)
Humphrey Castings, Inc., Calif (a,b,f,g)
Illinois Precise Casting Co., Ill (a,b,f,g)
Investment Casting Co., NJ (a,b,c,f,g)
Joseff-Hollywood Co., Calif (a,b,c,g)
Kolcast Industries Div., Thompson Products, Inc., Ohio (a,c,f,g)
Lawrence Laboratory, Calif (a,b,e)
Lebanon Steel Foundry, Pa (g)
Linton Precision Casting Co., Ind (a,b,c,f,g,j)
Loeffler, J. M. Machine Co., Pa (b)
Lynn Casting Corp., Calif (a,b,d,f,g)
Manco Products, Inc., Mich (f,g)
Meehanite Metal Corp., NY (c)—Ad p 431
Midwest Precision Castings Co., Ohio (a,b,c,f,g)
Misco Precision Casting Co., Mich (c,f,g)—Ad p 419
National Precision Casting Corp., Div. of Beryllium Corp., Pa (a,b,c,f,g)
Omni-Metal Castings, Inc., NY (a,b,c,f,g)
Picco, Inc., Calif (a,b,c,f,g)
Precision Castparts Corp., Ore (b,f,g)
Precision Founders, Inc., Calif (a,b,c,f,g,j)
Precision Metalsmiths, Inc., Ohio (a,b,c,d,f,g)
Pyromet Co., Calif (f,g)
Rausch Mfg. Co., Inc., Minn (a,b)
Rockwell Engineering Co., Ill (a,b,c,g)
Rode, Inc., Mass (a,b)
Rolle Mfg. Co., Pa (a,b,e,f,g)
Solon Foundry, Inc., Ohio (a,e)
Star Heel Plate Co., Inc., NJ (a,b)
Staver Co., Inc., NY (d)
Thompson, K.W. Tool Co., NY (a,b,c,e,f,g,h,j)
Thys Co., Calif (a,b,c,f,g)
United Shoe Machinery Corp., Mass (g)
Uniworld Research Corp. of America, Ohio (c,f)
Vascoloy-Ramet Corp., Ill (b,g)
Wall Colmonoy Corp., Mich (c,f)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (a,b,c,f,g,h)
York Casting, Inc., NY (a,b,c,f,g,j)
Z & H Mfg. Co., NY (a,b,c,e,f,g,h,j)

Castings, Nonmetallic

(plastics and rubber)

Ace Plastic Co., NY (l)
Acushnet Process Co., Mass (m)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (k,l)
Allied Resinous Products, Inc., Ohio (k)
American Agile Corp., Ohio (k)
Amos Molded Plastics Div., Amos-Thompson Corp., Ind (k)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Auburn Plastic Engineering, Ill (k)
Automotive Rubber Co., Inc., Mich (m)
Biggs, Carl H. Co., Inc., Calif (k,l)
Boonton Molding Co., NJ (k,l,m)
Buckeye Molding Co., Ohio (k)
Cadillac Plastic & Chemical Co., Mich (k)
Campro Co., Ohio (k)
Cast Optics Corp., NJ (k,l)
Ceilcote Co., Ohio (l)
Chemical Coatings & Engineering Co., Pa (k,l,m)
Chemical Development Corp., Mass (l)
Conneaut Rubber & Plastics Co., Div. of U.S. Stoneware Co., Ohio (k)
Disogrin Industries Div., Pellon Corp., NY (m)
Douglas & Sturgess, Calif (l,m)
Duriron Co., Inc., Ohio (l)
Eby, Hugh H. Co., Pa (k,l)
Eclipse Plastic Industries, Inc., Fla (k)
Electric Auto-Lite Co., Ohio (k,l)
Electronic Production & Development, Inc., Chemical Div., Calif (k)
Eljay Corp., Md (l)
Emerson & Cuming, Inc., Mass (k,l,m)
Foss Mfg. Co., Id (l)
General Mills, Inc., Chemical Div., Ill (k,l)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Grimes Mfg. Co., Plastic Research Products, Ohio (l)
G. S. Plastics Co., Ohio (k,l,m)
Hays Mfg. Co., Pa (l)
Hysol Corp., NY (l)
Kerrco, Neb (k,l,m)
Kurz Kasch, Inc., Ohio (l)
Madin Plastics Inc., NJ (k)
Marblette Corp., NY (l)
Mechanical Rubber Products Co., NY (l)
Minnesota Rubber & Gasket Co., Minn (k,m)
Mobay Chemical Co., Pa (m)
Munray Products Div., Fanner Mfg. Co., Ohio (k,m)
New England Tape Co., Div. of United-Carr Fastener Corp., Mass (l)
Nopco Chemical Co., Plastics Div., NJ (k,l)
Olympic Plastics Co., Inc., Calif (l)
Permali, Inc., Pa (l)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa (k)
Pyrosil, Inc., Ohio (l)
Quelcor, Inc., Pa (k)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Sewell Mfg. Co., Mich (l)
Sierra Electric Corp., Calif (k,l)
Sierracin Corp., Calif (l)
Superior Plastics, Inc., Ill (k)
Sylvania Electric Products, Inc., Parts Div., Pa (k,l)
Thombert, Inc., Iowa (l,m)
Trostel, Albert Packing, Ltd., Wis (l)
Tuff Clad, Inc., Ohio (k)
U.S. Stoneware Co., Ohio (k)
Warren Plastics & Engineering, Inc., Mich (l)

Castings, Permanent Mold

A C F Industries, Inc., NY (a)
Abco Aluminum & Brass Works, Tex (a,d)
Acme Aluminum Foundry Co., Ill (a)
Advance Aluminum Castings Corp., Ill (a)
Alcasco Foundry, Ill (a,b)
Aluminum Alloys Corp., Mich (a)
Aluminum Co. of America, Pa (a)
Aluminum Casting & Engineering Co., Wis (a,j)
Aluminum Industries, Inc., Ohio (a)
Aluminum Permanent Mold Co., Mich (a)
American Aluminum Castings Co., NJ (a)
American Brake Shoe Co., NY (a,b,c,g,j)
American Metal Climax, Inc., NY (b)
Apex Steel Corp., Ltd., Calif (g)
Aurora Metal Co., Ill (a,b)
Baldt Anchor, Chain & Forge Div., Boston Metals Co., Pa (a,b)
Belmont Smelting & Refining Works, Inc., NY (a,d,j)
Bendix Foundries Div., Bendix Aviation Corp., NJ (a,e)
Bohn Aluminum & Brass Corp., Mich (a)
Briggs-Shaffner Co., NC (a)
Bronze & Steel Die Casting Co., Ill (b)
Buckeye Brass & Mfg. Co., Ohio (a,b,j)
Bunker Hill Co., Calif (d,j)
Bunting Brass & Bronze Co., Ohio (a,b)
Calumet Div., Calumet & Hecla, Inc., Mich (c)
Centrifugal Casting Machine Co., Okla (a)
Centr-O-Cast & Engineering Co., Mich (a)
Chattanooga Aluminum Foundry, Inc., Tenn (a)
Cochrane Foundry, Inc., Pa (a,b,j)
Crobalt, Inc., Mich (g)
Crown Metal Co., Wis (d)
Davis Products Corp., NY (j)
Dayton Malleable Iron Co., Ohio (a)
Derby Castings Co., Conn (a)
Dirilyte Co. of America, Inc., Ind (b)
Division Lead Co., Ill (d)
Dixie Bronze Co., Ala (a,b,f)
Dostal Foundry & Machine Co., Mich (c)
Eaton Mfg. Co., Foundry Div., Mich (c)—Ad p 405
Eclipse-Pioneer Div., Bendix Aviation Corp., NJ (a,e)
Enterprise Wheel & Car Corp., Va (a)
Esco Corp., Ore (f,g)
Est Co., Inc., Wis (a,e)
Exalco Mfg. Co., Ohio (a)
Fairfield Aluminum Casting Co., Iowa (a)
Flynn, Michael Mfg. Co., Pa (a)
Forest City Foundries Co., Ohio (c)
Foster Aluminum Alloy Products Corp., NY (a)
General Aluminum Mfg. Co., Ohio (a,e)
General Casting Corp., NY (a,b,c,e,f,g,h,j)
General Electric Co., Foundry Dept., NY (a,b,c)
General Motors Corp., Fabricast Div., Ind (a)
Central Foundry Div., Mich (a)
Gilbert Brass & Foundry Co., Mo (a)
Gillett & Eaton, Inc., Minn (a,c)
Hampden Brass & Aluminum Co., Mass (a)
Harvill Corp., Calif (a,e)
Howard Foundry Co., Ill (a,e)
Humphrey Castings, Inc., Calif (a)
Janney Cylinder Co., Pa (a,b,c,f,g)
Johnson Bronze Co., Pa (b)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Lebanon Steel Foundry, Pa (g)
Light Metals, Inc., Ind (a,e)
Light Metals Dept., American Brake Shoe Co., NJ (a,e)
Littlestown Hardware & Foundry Co., Inc., Pa (a)
Magline, Inc., Mich (a,e)
Magnolia Metal Co., NJ (b)
Mallory, P.R. & Co., Inc., Ind (h)
Manco Products, Inc., Mich (b)
Manor Die Cast Corp., Ohio (a)
Mansfield Brass & Aluminum Corp., Ohio (a)
Marshall Car & Wheel Foundry Co., Inc., Tex (c)
McLanahan & Stone Corp., Pa (c)
Meehanite Metal Corp., NY (c)—Ad p 431
Meta-Mold Aluminum Co., Sub of Dayton Malleable Iron Co., Wis (a,e)
Moccasin Bushing Co., Tenn (b)
Mohawk Foundries, Inc., Ohio (a)
Moldcast Products, Inc., NJ (a)
Monarch Aluminum Mfg. Co., Ohio (a)
Morse, Fred W. Co., RI (a,j)
National Aluminum Mfg. Co., Ill (a)
National Lead Construction Co., Inc., Pa (d)
Nuclear Metals, Inc., Mass (a,b,c,e,f,g,h)
Olds Alloys Co., Calif (b,d,f)
Oregon Metallurgical Corp., Ore (h)
Parker, Charles Co., Conn (a,j)
Peasley Products, Inc., Conn (a,j)
Permold Co., Ohio (a)
Philadelphia Bronze & Brass Corp., Pa (a,b,f)
Quality Aluminum Casting Co., Wis (a)
Rockwell Engineering Co., Ill (a,b,c,g)
Rolle Mfg. Co., Pa (a,e)
Saginaw Bay Industries, Inc., Mich (a,e)
Sandusky Foundry & Machine Co., Ohio (b,f,g)
Schilling Bronze Co., NY (a,b,d,f,j)
Schmeller Aluminum Foundry Co., Ohio (a)
Sorbo-Mat Process Engineers, Mo (c)
Standard Magnesium Corp., Okla (e)
Star Heel Plate Co., Inc., NJ (a,b)
Staver Co., Inc., NY (d)
Sterling Aluminum Products, Inc., Mo (a)
Stewart-Warner Corp., Stewart Die Casting Div., Ill (a)
Superb Light Alloys, Inc., NY (a,e)
Texas Foundries, Inc., Tex (c,g)
Thompson Products, Light Metals Div., Ohio (a)
Tickle, Arthur Engineering Works, Inc., NY (a)
True Alloys, Inc., Mich (a,b,d,j)
Universal Castings Corp., Ill (a,b)
Vulcan Rail & Construction Co., NY (a,c)
Waterman Industries, Inc., Calif (a)
Wellman Bronze & Aluminum Co., Ohio (a,e)
Williams, A.C. Co., Ohio (e)
Winters Foundry & Machine Co., Inc., Ohio (a)
Wisconsin Aluminum Foundry Co., Inc., Wis (a,b)

KEY

MATERIALS

a—Aluminum and its alloys	e—Magnesium and its alloys	j—Zinc and its alloys
b—Copper and its alloys	f—Nickel and its alloys	k—Thermoplastics
c—Iron and its alloys (except steel)	g—Steels	l—Thermosetting plastics
d—Lead and its alloys	h—Titanium and its alloys	m—Elastomers

BASIC FORMS

n—Anodes	r—Custom formed parts (incl. specialties)	v—Foil	aa—Powder
o—Bar	s—Fibers	w—Ingot	bb—Rod
p—Base resins, polymers or gums	t—Film	x—Laminating, casting resins	cc—Sheet
q—Billets	u—Foams (component materials or products)	y—Molding compounds	dd—Strip
		z—Plate	ee—Tubing
			ff—Wire

Castings, Plaster Mold

All Metals Precision Casting Corp., NY (a,b)
Alloy Precision Castings Co., Ohio (a, b,c,e,f,g)
Aluminum Co. of America, Pa (a)
American Aluminum Casting Co., NJ (a)
Atlantic Casting Engineering Corp., NJ (a,b)
Bean, Morris & Co., Ohio (a)
Beloit Foundry Co., Ill (c)
Bendix Foundries Div., Bendix Aviation Corp., NJ (a)
Chattanooga Aluminum Foundry, Inc., Tenn (a)
Curtiss-Wright Corp., NY (g)
Derby Castings Co., Conn (a)
Eclipse-Pioneer Div., Bendix Aviation Corp., NJ (a,e)
General Motors Corp., Fabricast Div., Ind (a)
Central Foundry Div., Mich (a)
Hampden Brass & Aluminum Co., Mass (a)
Humphrey Castings, Inc., Calif (a)
Larson, W. O. Foundry Co., Ohio (c)
Lebanon Steel Foundry, Pa (g)
Light Metals Dept., American Brake Shoe Co., NJ (a)
Lincoln Foundry Corp., Calif (c)
Loeffler, J. M. Machine Co., Pa (b)
Meehanite Metal Corp., NY (c)—Ad p 431
Ohio Precision Castings, Inc., Ohio (a,b,f)
Olderman Mfg. Corp., Conn (b)
Rockwell Engineering Co., Ill (a,b,c,g)
Ross-Meehan Foundries, Tenn (c,g)
Schilling Bronze Co., NY (a,b,d,f,j)
Schneider, Bowman Co., Inc., Pa (c)
Solon Foundry, Inc., Ohio (a,e)
Sorbo-Mat Process Engineers, Mo (c)
True Alloys, Inc., Mich (a,b)
Universal Castings Corp., Ill (a,b)
Vanadium-Alloys Steel Co., Pa (g)
Wayne Foundry & Stamping Co., Mich (j)
Western Iron & Foundry Co., Inc., Kan (c)

Castings, Sand

Abco Aluminum & Brass Works, Tex (a,b,d,f,j)
Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa (b, c,g)
Acme Aluminum Foundry Co., Ill (a)
Acme Foundry & Machine Co., Kan (c)
Acme Foundry & Machine Co., Okla (c)
Advance Foundry Co., Ohio (c)
Aelco Foundries, Inc., Wis (a,b,d,e, f,g)
Albany Car Wheel Co., Inc., NY (c)
Albert Lea Foundry-Queen Products Div., King-Seeley Thermos Co., Minn (c)
Albion Malleable Iron Co., Mich (c)
Alcasco Foundry, Ill (a,b)
Allegheny Foundry Co., Pa (c)
Allegheny Ludlum Steel Corp., Pa (g)
Allied Steel Castings Co., Ill (g)
Alloy Cast Steel Co., Ohio (g)
Alloy Steel Casting Co., Pa (f,g)
Almont Mfg. Co., Mich (c)
Alten Foundry & Machine Works, Inc., Ohio (c)
Aluminum Alloys Corp., Mich (a)
Aluminum Co. of America, Pa (a,e)
Aluminum Industries, Inc., Ohio (a)
Aluminum Permanent Mold Co., Mich (a)
Amalgamated Steel Corp., Ohio (g)
American Aluminum Casting Co., NJ (a)
American Brake Shoe Co., NY (a, b,j)
American Car & Foundry Div., ACF Industries, Inc., NY (c)
American Cast Iron Pipe Co., Ala (c,f,g)
American Crucible Products Co., Ohio (b)
American Foundries Co., Mich (c)
American Laundry Machinery Co., NY (c)
American Light Alloys, Inc., NJ (a, e)
American Manganese Steel Div., American Brake Shoe Co., Ill (g)
American Metal Climax, Inc., NY (b)
American Sanitary Mfg. Co., Ill (b)
American Steel Foundries, Ind (g)
American Steel Foundries, Ill (g)
Ampco Metal, Inc., Wis (b)
Apex Foundry, Inc., Mich (c,e,f)
Apex Steel Corp., Ltd., Calif (g)
Arkansas Foundry Co., Ark (c)
Arneson Foundry Co., Wis (c,g)
Arnold Engineering Co., Ill (a,c,f)
Arzt, T.L. Foundry Co., Ill (c)
Atlantic Foundry Co., Ohio (c,g)
Atlantic Steel Castings Co., Pa (g)
Atlas Brass Foundry, Calif (b)
Atlas Foundry Co., Ohio (c)
Atlas Foundry & Machine Co., Wash (c,g)
Atlas Foundry & Mfg. Co., Calif (c)
Auto Specialties Mfg. Co., Mich (c)
Badger Malleable & Mfg. Co., Wis
Baldwin-Lima-Hamilton Corp., Pa (a, b,f,g)
Banner Iron Works, Mo (c)
Barnard Foundry Co., Inc., Mass (b)
Barnett Foundry & Machine Co., NJ (c)
Baxter Foundry & Machine Works, Inc., Id (a,b,c)
Bay City Electric Steel Casting Co., Mich (g)
Bay City Foundry Co., Mich (c)
Bay State Tool & Machine Co., Mass (g)
Bean, Morris & Co., Ohio (c)
Bearium Metals Corp., NY (b)
Beaver Valley Alloy Foundry Co., Pa (c,g)
Bellaire Stove Co., Ohio (c)
Belle City Malleable Iron Co., Wis (c,g)
Beloit Foundry Co., Ill (c)
Bendix Foundries Div., Bendix Aviation Corp., NJ (a,e)
Beryllium Corp., Pa (b)
Bethlehem Steel Co., Pa (c,g)
Bierman-Everett Foundry Co., NJ (a, b,c)
Bignall Co., NY (c)
Black-Clawson Co., Ohio (c)
Blaw-Knox Co., Pa (f,g)
Bond, Charles Co., Pa (c)
Bonnot Co., Ohio (c)
Briggs-Shaffner Co., NC (a,c)
Brillion Iron Works, Inc., Wis (c)
Brinkerhoff Brass & Bronze Works, Inc., NY (a)
Bruce Foundry and Mfg. Co., Mich (c)
Buckeye Iron & Brass Works, Ohio (a,b)
Bunting Brass & Bronze Co., Ohio (b)
Butler Engine & Foundry Co., Inc., Pa (a,b,c)
Cadillac Malleable Iron Co., Mich (c)
Calorizing Co., Pa (f,g)
Calumet Div., Calumet & Hecla, Inc., Mich (c)
Calumet Steel Castings Corp., Ind (g)
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich (c,g)
Canton Malleable Iron Co., Ohio (c)
Carondelet Foundry Co., Mo (c,f,g)
Case, J.I. Co., Wis (c)
Castalloy Co., Inc., Mass (a,e)
Casting Service Corp. of Michigan, Mich (c)
Central Specialty Div., King-Seeley Thermos Co., Mich (c)
Chain Belt Co., Wis (c)
Chambersburg Engineering Co., Pa (c)
Chattanooga Aluminum Foundry, Inc., Tenn (a)
Chicago Aluminum Castings, Ill (a)
Chicago Hardware Foundry Co., Ill (a,b,c)
Chicago Malleable Castings Co., Ill (c)
Clark Bros. Co. Div., Dresser Operations, Inc., NY (c)
Clarksville Foundry & Machine Works, Tenn (c)
Cleveland Foundry & Mfg. Co., Inc., Tenn (c)
Clinton Metal Products Co., Ohio (a)
Coast Metals, Inc., NJ (c,f)
Cochrane Foundry, Inc., Pa (a,b,j)
Columbian Bronze Corp., NY (a,b,d)
Columbiana Pump Co., Ohio (c)
Commercial Iron Works, Calif (c)
Commercial Steel Casting Co., Ohio (g)
Compton Foundry, Calif (c)
Continental Gin Co., Ala (c)
Cooper Alloy Corp., NJ (g,h)
Cooper-Bessemer Corp., Ohio (c)
Copper & Brass Sales, Inc., Mich (c)
Crawford & Doherty Foundry Co., Ore (c)
Crown Non-Ferrous Foundry, Inc., Pa (a,b,f)
Crucible Steel Casting Co., Pa (g)
Curtiss-Wright Corp., Metals Processing Div., NY (f,g)
Dalton Foundries, Inc., Ind (c)
Darling Valve & Mfg. Co., Pa (c)
Dayton Bronze Bearing Co., Ohio (a,b)
Dayton Foundry, Calif (c)
Dayton Malleable Iron Co., Ohio (a, c)
Decatur Casting Co., Ind (c)
Decrow Engineering Corp., NY (a,b)
De Laval Steam Turbine Co., NJ (c)
Derby Castings Co., Conn (a,b)
De Sanno Foundry & Machine Co., Calif (a,b)
Detroit Brass & Malleable Co., Mich (c)
Deuscher, H. P. Co., Ohio (c)
Dexter Foundry Div., Philco Corp., Iowa (c)
Dirilyte Co. of America, Inc., Ind (b)
Division Lead Co., Ill (d)
Dixie Bronze Co., Ala (a,b,f)
Dodge Steel Co., Pa (g)
Dormont Mfg. Co., Pa (b)
Driver-Harris Co., NJ (f)
Ductile Iron Foundry, Inc., Conn (a,c)
Duluth Brass Works Co., Minn (a,b)
Duraloy Co., Pa (g)—Ad p 429
Duriron Co., Inc., Ohio (c,g)
East Birmingham Bronze Foundry Co., Ala (a,b)
Eastern Malleable Iron Co., Del (g)
Eclipse-Pioneer Div., Bendix Aviation Corp., NJ (a,e)
Ehrsam, J.B. & Sons Mfg. Co., Kan (c)
Eichinger, Charles F., La (a,b)
Electric Materials Co., Pa (b)
Electro-Alloys Div., American Brake Shoe Co., Ohio (g)
Electron Corp., Colo (c,f)
Elk Engineering Works, Inc., Pa (a,b,c)
Elkhart Foundry & Machine Co., Inc., Ind (c)
Elkhart Iron Works, Mich (c)
Elyria Foundry Div., Chromalloy Corp., Ohio (c)
Emmaus Foundry & Machine Co., Pa (a,b,c)
Empire Foundry Co., Inc., Calif (c,g)
Empire Steel Castings, Inc., Pa (g)
Engineered Castings Div., American Brake Shoe Co., NY (c)
Enterprise Wheel & Car Corp., Va (a, b,c)
Erie Bronze Co., Pa (a,b)
Erie Casting Co., Pa (c)
Erie Malleable Iron Co., Pa (c)
Esco Corp., Ore (f,g)
Eureka Electric Products Inc., Pa (a,b)
Fahralloy Co., Ill (g)
Fairbanks, Morse & Co., Wis (c)
Fairfield Aluminum Castings Co., Iowa (a)
Falcon Foundry Co., Ohio (a,b,e)—Ad p 154
Falk Corp., Wis (g)
Federal Malleable Co., Wis (c)
Fischer Casting Co., Inc., NJ (c)
Fitchburg Foundry, Inc., Mass (c)
Flood City Brass & Electric Co., Pa (a,b)
Florence Pipe Foundry & Machine Co., NJ (c)
Florin Foundry & Mfg. Co., Pa (c)
Forest City Foundries Co., Ohio
Fort Pitt Steel Casting Div., Pittsburgh Steel Foundry Corp., Pa (f,g)
Fort Worth Steel & Machinery Co., Tex (c)
Foster Aluminum Alloy Products Corp., NY (a)
Frederick Iron & Steel, Inc., Md (c)
Fremont Casting Co., Mass (c)
Frontier Bronze Corp., NY (a,b,f)
Fulton Foundry & Machines Co., Inc., Ohio (c)
G & C Foundry Co., Ohio (c)
Gale Mfg. Co., Mich (c)
Gartland Foundry Co., Ind (c)
General Alloys Co., Mass (f)
General Electric Co., Foundry Dept., NY (a,b,c,f,g)
General Foundry & Mfg. Co., Mich (c)
General Malleable Corp., Wis (c)
General Metals Corp., Calif (c)
General Motors Corp., Central Foundry Div., Mich (a,c)
Fabricast Div., Ind (a)
General Steel Castings Corp., Ill (g)
Georgia Iron Works, Ga (c)
Gibson & Kirk Co., Md (a,b,f)
Gilbert Brass Foundry Co., Mo (a,b)
Gillett & Eaton, Inc., Minn (a,c)
Glover Machine Works, Ga (g)
Gluntz Brass & Aluminum Foundry Co., Ohio (a,b,j)
Goslin Birmingham Mfg. Co., Inc., Ala (c,g)
Gowanda Furnaces, Inc., NY (c)
Grafton Foundry Co., Wis (c)
Gra-Iron Foundry Corp., Iowa (c)
Green Bay Foundry & Machine Works, Wis (a,b,c)
Greenlee Foundry Co., Ill (c)
Grimm Foundry Co., Inc., NJ (c)
Gunite Foundries Corp., Ill (c,g)
H & H Foundry Machine Co., Pa (c)
Hallstead Foundry, Inc., Pa (c)
Hamilton Foundry Inc., Ohio (c)
Hampden Brass & Aluminum Co., Mass (a,b,j)
Hansell-Elcock, Ill (c)
Hardinge Mfg. Co., Pa (c)
Hartford Electrical Steel Corp., Conn (g)
Haynes Stellite Co., Div. of Union Carbide Corp., NY (f)
Hays Mfg. Co., Pa (b)
Headford Bros. & Hitchins Foundry Co., Iowa (c)
Helmick Foundry-Machine Co., W.Va (c)
Hewitt, John Foundry Co., NJ (a,b,c)
Hica, Inc., La (f,g)
Hills-McCanna Co., Ill (a,e)
Hobbs, Clinton E. Co., Mass (a,b,c)
Hodgson Foundry Co., Ill (a,b,c,d)
Hoffman Bronze & Aluminum Casting Co., Ohio (a,b)
Homestead Valve Mfg. Co., Pa (a,b,c, f)
Howard Foundry Co., Ill (a,b,c,e,f,g)
Humphrey Castings, Inc., Calif (a)
Huntington Alloy Products Div., International Nickel Co., Inc., W.Va (f)
Hunt-Spiller Mfg. Corp., Mass (c,g)
I-F Mfg. Co., Ohio (c)
Illinois Iron & Bolt Co., Ill (a,f)
Independence Stove & Mfg. Co., Mo (c)
Indiana Brass Co., Inc., Ind (b)
Industrial-Ferguson Foundry Corp., NJ (a,b,f,j)
Iowa Malleable Iron Co., Iowa (c)
Ironton Malleable Div., Dayton Malleable Iron Co., Ohio (c)
Irwin-Sensenich Corp., Pa (c)
Jamestown Malleable Iron Corp., NY (c)
Jessop Steel Co., Pa (c,g)
Johnson Bronze Co., Pa (b)
Johnstone Foundries, Inc., Pa (c)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)

Kansas City Hay Press Co., Mo (c)
Kay-Brunner Steel Products, Inc., Calif (g)
Keen Foundry Co., Inc., Ind (c)
Kelly Foundry Co., Pa (c)
Kingsport Foundry & Mfg. Corp., Tenn (a,b,c,f)
Klinzing, A.F. Co., Inc., Wis (c,g)
Koehring Co., Wis (c)
Kramer Bros. Foundry Co., Ohio (c)
Kutztown Foundry & Machine Corp., Pa (c)
L F M Mfg. Co., Inc., Sub. of Rockwell Mfg. Co., Kan (g)
Laconia Malleable Iron Co., NH (c)
Lake Erie Foundry Co., NY (c)
Lakeside Bronze, Inc., NY (a,b)
Lakeside Malleable Casting Co., Wis (c)
Langenkamp-Wheeler Brass Works, Inc., Ind (a,b)
La Porte Foundry Co., Ind (c)
Larson, W.O. Foundry Co., Ohio (c)
Lattimer Foundry and Machine Co., Pa (a)
Lawrence Copper & Bronze Co., Pa (b)
Lawton, C. A. Co., Wis (a,c)
Lebanon Steel Foundry, Pa (g)
Le Baron, E. L. Foundry, Mass (c)
Lee Bros. Foundry Co., Inc., Ala (b)
Lehigh Foundries Co., Div. of Lehigh, Inc., Pa (c)
Leitelt Bros., Inc., Ill (a,b)
Letukas Foundry Inc., Ind (c)
Lewistown Foundry & Machine Co., Pa (a,c,d)
Liberty Foundry Co., Mo (c,g)
Light Metals, Inc., Ind (a,e)
Light Metals Dept., American Brake Shoe Co., NJ (a)
Lincoln Foundry Corp., Calif (c)
Lincoln Iron Works, Vt (a,c)
Link-Belt Co., Ill (c)
Little Foundries, Inc., Mich (c)
Littlestown Hardware & Foundry Co., Inc., Pa (a,b,c)
Lloyd & Scott Brass Foundry, Inc., Del (a,b)
Lodge Mfg. Co., Tenn (c)
Lodi Iron Works, Inc., Calif (c)
Loeffler, J. M. Machine Co., Pa (b)
Long Beach Iron Works, Calif (c)
Long Foundry Co., Wash (c)
Lorain Brass Co., Ohio (b)
Los Angeles Steel Casting Co., Calif (g)
Ludlow Valve Mfg. Co., Inc., NY (c)
Lumen Bearing Co., NY (b,d,j)
Lynchburg Foundry Co., Castings Div., Va (c)
Macaulay, H.C. Foundry Co., Calif (c)
Mackintosh-Hemphill Div., E.W. Bliss Co., Pa (g)
Madison Foundry Co., Ohio (c)
Magline, Inc., Mich (a,e)
Mallory, P.R. & Co., Inc., Ind (b,f,h)
Manco Products Inc., Mich (b)
Mansfield Brass & Aluminum Corp., Ohio (a,b)
Marshall Car Wheel & Foundry Co., Inc., Tex (c)
Massillon Steel Casting Co., Ohio (g)
McLanahan & Stone Corp., Pa (c)
McNally Pittsburgh Mfg. Co., Kan (c)

Meadville Malleable Iron Co., Pa (c)
Meehanite Metal Corp., NY (c)—Ad p 431
Merrimac Brass, Mass (a,b,d,e,f)
Merriman Bros., Inc., Mass (b)
Metropolitan Iron Foundry, NY (a,c)
Midwest Foundry Co., Div. of L.A. Darling Co., Mich (c,g)
Midwestern Foundries, Inc., Ind (c)
Milwaukee Aluminum & Brass Foundry, Wis (a,b)
Milwaukee Malleable & Grey Iron Works, Wis (c)
Milwaukee Valve Co., Wis (a,b)
Minneapolis Electric Steel Castings Co., Minn (g)
Missouri Steel Castings Co., Mo (g)
Moccasin Bushing Co., Tenn (b)
Model Brass Co., Inc., Ill (a,b)
Modern Brass Foundry & Mfg. Co., Ohio (a,b)
Mohawk Foundries, Inc., Ohio (a)
Moline Malleable Iron Co., Ill (c)
Monroe Steel Castings Co., Mich (g)
Montague Machine Co., Mass (c,f)
Moore Dry Dock Co., Calif (b,g)
Morrisville Foundry Co., Inc., Vt (c)
Morse, Fred W. Co., RI (a,j)
Mount Vernon Furnace & Mfg. Co., Ill (c)
Mueller Brass Co., Mich (a,b)—Ad p 404
Muskegon Piston Ring Co., Mich (b, c)
National Aluminum Co., Inc., Wis (a,b)
National Aluminum & Brass Foundry, Inc., Mo (a,b)
National Bearing Div., American Brake Shoe Co., Pa (b)
National Brass Works, Inc., Calif (a,b,d,f)
National Grey Iron Foundry, Ill (c)
National Malleable & Steel Castings Co., Ohio (c,g)
National Steel & Shipbuilding Corp., Calif (c)
National Supply Div., Armco Steel Corp., Pa (g)
Neenah Foundry Co., Wis (c)
Newman Bros., Inc., Ohio (a,b)
Noble & Wood Machine Co., NY (c)
Northern Malleable Iron Co., Minn (c)
Nutmeg Crucible Steel Co., Conn (g)
Oak Hill Foundry & Machine Works, Ohio (c)
Oakes Bronze & Aluminum Co., Ohio (a,b)
Oakland Foundry & Machine Co., Mich (c)
Ohio Malleable Div., Dayton Malleable Iron Co., Ohio (c)
Ohio Precision Castings, Inc., Ohio (a,b,f)
Ohio Steel Foundry Co., Ohio (f,g)
Oil City Iron Works, Tex (c)
Oklahoma Steel Castings Div., American Steel & Pump Corp., Okla (g)
Olderman Mfg. Corp., Conn (b)
Olds Alloys Co., Calif (a,b,d,f)
Olympic Steel Works, Wash (g)
Omaha Steel Works, Neb (g)

Oregon Brass Works, Ore (a,b)
Oregon Metallurgical Corp., Ore (h)
Overmyer Mould Co., Inc., Ind (c,f,g)
Owen Pattern Foundry & Mfg Co., Inc., Va (a,b)
Pacific Brass Foundry of San Francisco, Calif (a,b,d,f,j)
Pacific Foundry & Metallurgy Co., Calif (c,g)
Palmyra Foundry Co., Inc., NJ (c)
Parker, Charles Co., Conn (a,b)
Parker-Street Castings Co., Ohio (c)
Paulson, Thomas & Son, Inc., NY (a,b,f,j)
Payne, F.S. Co., Mass (c)
Pelton Steel Casting Co., Wis (g)
Penn Steel Castings Co., Pa (g)
Peoria Malleable Casting Co., Ill (c)
Pequonnock Foundry, Inc., Conn (c)
Perfect Circle Co., Ind (c)
Perfecto Cast, Calif (f,g)
Perkins, Henry Co., Mass (c)
Permold Co., Ohio (a)
Pettibone Mulliken Corp., Ill (g)
Philadelphia Bronze & Brass Corp., Pa (a,b,f)
Pittsburgh Foundry & Machine Co., Pa (c)
Pittsburgh Steel Foundry Corp., Pa (g)
Pohlman Foundry Co., Inc., NY (c)
Portland Iron Works, Ore (c)
Posey Iron Works, Inc., Pa (c)
Potts, C. & G. Co., Ind (c)
Prescott Co., Mich (a,c)
Pusey & Jones Corp., Del (c)
Quaker Alloy Casting Co., Pa (c,f,g)
Quality Aluminum Casting Co., Wis (a)
Quality Electric Steel Castings, Inc., Tex (g)
Quincy Steel Casting Co., Mass (g)
Racine Steel Castings Co., Belle City Malleable Iron Div., Wis (c)
Refinery Castings Co., Tex (c)
Reliance Foundry Co., Ohio (c)
Rensselaer Valve Co., NY (c)
Richmond Foundry & Mfg. Co., Inc., Va (a,b,c,d,f,j)
Ridge Foundry, Calif (c)
Riverside Foundry & Galvanizing Co., Mich (a,b,c,f)
Rockwell Engineering Co., Ill (a,b,c,g)
Rolle Mfg. Co., Pa (a,e)
Rosedale Foundry & Machine Co., Pa (c)
Ross-Meehan Foundries, Tenn (c,g)
Saginaw Bearing Co., Mich (a,b)
St. Louis Malleable Casting Co., Mo (c)
St. Louis Steel Casting, Inc., Mo (g)
St. Marys Foundry Co., Ohio (c)
Sall Bros. Co., Ill (a,b)
San Francisco Iron Foundry, Calif (a,b,c)
Sandy Hill Iron & Brass Works, NY (a,b,c)
Saran Lined Pipe Co., Div. of Michigan Pipe Co., Mich (c,g)
Sargent & Greenleaf, Inc., NY (a,b)
Savannah Machine & Foundry Co., Foundry Div., Ga (a,b,c,d)
Schaefer-Goodnow Foundries, Inc., Pa (c)
Schilling Bronze Co., NY (a,b,d,f,j)

Schmeller Aluminum Foundry Co., Ohio (a)
Schneider, Bowman Co., Inc., Pa (c)
Scottdale Ozone Co., Pa (a,c)
Scovill Mfg. Co., Mill Products Div., Conn (a,b)
Scudder, E. J. Foundry & Machine Co., NJ (f,g)
Scullin Steel Co., Mo (g)
Selma Foundry & Machine Co., Ala (c)
Sequoia Metalcraft Co., Inc., Calif (a)
Shakopee Foundry Co., Minn (c)
Shartle Div., Black-Clawson Co., Ohio (a,b,c)
Sheffield Foundry Co., Ill (c)
Sherman & Reilly, Inc., Tenn (a, c,g)
Shriver, T. & Co., Inc., NJ (a,b,c,d)
Sibley Machine & Foundry Corp., Ind (c)
Sillcocks Miller Co., NJ (b,j)
Sinclair Co., Mass (a,b)
Sioux City Foundry & Boiler Co., Iowa (a,c)
Sivyer Steel Casting Co., Wis (g)
Smith, A.P. Mfg. Co., NJ (c)
Smith & Winchester Mfg. Co., Conn (a,b,c,g)
Solon Foundry, Inc., Ohio (a,b,e)
Somerset Foundry & Machine Co., Pa (a,c,d)
Sonith Foundries Div., Food Machinery & Chemical Corp., Ind (b,c)
Sorbo-Cast Corp., NJ (c)
Sorbo-Mat Process Engineers, Mo (a)
Southern Metal Products Co., La (a)
Sparta Foundry Div., Muskegon Piston Ring Co., Mich (c)
Spencer's, I. S. Sons, Inc., Conn (a, b,c)
Spring City Foundry Co., Pa (c)
Springer's Foundry Co., Inc., Ind (a,c)
Springfield Foundry Co., Mass (c)
Spuck Iron & Foundry Co., Mo (c)
Stainless Foundry & Engineering, Inc., Wis (f)
Standard Casting Corp., Ill (a,b,d)
Standard Foundry Co., Mass (c)
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (g)
Star Heel Plate Co., Inc., NJ (c,g)
State Foundry & Machine Co., Wis c)
Stearns-Roger Mfg. Co., Colo (c)
Sterling Brass Foundry, Inc., Ind (c)
Sterling Foundry Co., Inc., Ill (a, b,c)
Sterrit-Thomas Foundry Co., Pa (c)
Stillman White Foundry Co., Inc., RI (a,b,d)
Strong Steel Foundry Co., NY (g)
Stulz-Sickles Co., NJ (g)
Superb Light Alloys, Inc., NY (a,e)
Superior Foundry, Inc., Ohio (c,g)
Swayne-Robinson & Co., Ind (a,c)
Swedish Crucible Steel Co., Mich (g)
Swett, A.L. Iron Works, NY (c)
Symington Div., Symington Wayne Corp., NY (g)
Taylor & Co., Inc., NY (c)
Taylor & Boggis Foundry, Ohio (c)
Taylor & Fenn Co., Conn (a,c)
Taylor-Wharton Co., Div. of Harsco Corp., NJ (g)
Terre Haute Bronze & Brass Foundry, Ind (b)
Terre Haute Malleable & Mfg. Corp., Ind (c)
Texas Foundries, Inc., Tex (c,g)
Thys Co., Calif (g)
Tickle, Arthur Engineering Works, Inc., NY (a)
Tower Grove Foundry, Mo (c)
Trenton Brass Co., NJ (b)
True Alloys, Inc., Mich (a,b,d,j)
Turner & Seymour Mfg. Co., Conn (c)
Union Iron Works, Wash (c,g)
Unitcast Corp., Ohio (g)
U.S. Magnet & Alloy Corp., NJ (c, f,g)
Uniworld Research Corp. of America, Ohio (c,f)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Utica General Jobbing Foundry, Inc., NY (c)
Utica Radiator Corp., NY (c)
Valley Iron Works, Inc., Minn (c)
Valley Steel Casting Co., Mich (g)
Vanadium-Alloys Steel Co., Pa (g)
Viking Pump Co., Iowa (a,b,c,f,g)
Vollrath Co., Wis (a,b,g)
Vulcan Foundry Co., Calif (c)
Vulcan Rail & Construction Co., NY (a,c,g)
Wagner Malleable Iron Co., Ill (c)
Wall Colmonoy Corp., Stainless Process Div., Mich (c,f)
Waltham Foundry Co., Mass (a,c)
Washington Iron Works, Wash (c)
Waterman Industries, Inc., Calif (a, b,c)
Waukesha Foundry Co., Wis (a,b,f,g)
Wayne Agricultural Works, Inc., NC (b,c)
Wayne Foundry & Stamping Co., Mich (d,j)
Weber-Knapp Co., NY (a)
Webster Mfg. Inc., Ohio (c)
Wellman Bronze & Aluminum Co., Ohio (a,e)
Werner Foundry & Machine Co., Pa (c)
West Haven Foundry Co., Conn (a,b,d, f,j)
West Point Foundry & Machine Co., Div. of Batson-Cook Co., Ga (a,c,d)
West Steel Casting Co., Ohio (f,g)
Western Automatic Machine Screw Co., Ohio (c)
Western Foundry & Machine Works, Inc., Kan (c)
Western Iron & Foundry Co., Inc., Kan (c)
Westlectric Castings, Inc., Calif (g)
Westmoreland Malleable Iron Co., NY (a,c,g)
Williams, A.C. Co., Ohio (e)
Williams, E.A. & Son, NJ (a,b)
Winters Foundry & Machine Co., Inc., Ohio (a,b,d,f,j)
Wisconsin Aluminum Foundry Co., Inc., Wis (a,b)
Wollaston Foundry Corp., Mass (c)
Woodruff & Edwards, Inc., Ill (c)
Worthington Corp., NJ (c)
Zenith Foundry Co., Wis (c)

Castings, Shell Mold

Abco Aluminum & Brass Works, Tex (a,b,d,f,j)
Aelco Foundries, Inc., Wis (a,b,f,g)
Albion Malleable Iron Co., Mich (c)
Alloy Precision Castings Co., Ohio (a, b,c,e,f,g)
Alloy Steel Casting Co., Pa (f,g)
Almont Mfg. Co., Mich (c)
American Aluminum Casting Co., NJ (a)
American Cast Iron Pipe Co., Ala (c)
American Manganese Steel Div., American Brake Shoe Co., Ill (g)
American Steel Foundries, Ill (g)
Ampco Metal, Inc., Wis (b)
Arwood Corp., NY (a,b,e,g)
Atlas Foundry & Mfg. Co., Calif (a,b, c,g)
Aurora Metal Co., Ill (b)
Austenal Co., Div. of Howe Sound Co., NY (a,c,f,g)
Auto Specialties Mfg. Co., Mich (g)
Baxter Foundry & Machine Works, Inc., Ind (c)
Bendix Foundries Div., Bendix Aviation Corp., NJ (a,e)
Bethlehem Steel Co., Pa (g)
Blaw-Knox Co., Pa (f,g)
Brillion Iron Works, Inc., Wis (c)
Buckeye Brass & Mfg. Co., Ohio (a,b)
Cadillac Malleable Iron Co., Mich (c)
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich (c)
Castalloy Co., Inc., Mass (a,e)
Chicago Hardware Foundry Co., Ill (a, b,c)
Chicago Malleable Castings Co., Ill (c)
Coast Metals, Inc., NJ (c,f)
Cochrane Foundry, Inc., Pa (a,b,j)
Cooper Alloy Corp., NJ (g)
Crawford & Doherty Foundry Co., Ore (c)
Crobalt, Inc., Mich (g)
Crucible Steel Casting Co., Pa (g)
Curtiss-Wright Corp., Metals Processing Div., NY (f,g)
Dayton Malleable Iron Co., Ohio (c)
Dirilyte Co. of America, Inc., Ind. (b)
Dodge Steel Co., Pa (g)
Duraloy Co., Pa
(f)—Ad p 429
Eaton Mfg. Co., Foundry Div., Mich (c)
Eclipse-Pioneer Div., Bendix Aviation Corp., NJ (a,e)
Electro-Alloys Div., American Brake Shoe Co., Ohio (g)
Electron Corp., Colo (c)
Emmaus Foundry & Machine Co., Pa (a,b,c)
Empire Steel Castings, Inc., Pa (g)
Erie Casting Co., Pa (c)
Esco Corp., Ore (f,g)
Fischer Casting Co., Inc., NJ (a)
Forest City Foundries Co., Ohio (c)
Fort Pitt Steel Casting Div., Pittsburgh Steel Foundry Corp., Pa (f,g)
Foster Aluminum Alloy Products Corp., NY (a)
Gale Mfg. Co., Mich (c)
General Casting Corp., NY (a,b,c,e, f,g,h,j)
General Electric Co., Foundry Dept., NY (f,g)
General Motors Corp., Central Foundry Div., Mich (c)
General Motors Corp., Fabricast Div., Ind (a)
Gilbert Brass Foundry Co., Mo (a,b)
Grimm Foundry Co., Inc., NJ (c)
Gunite Foundries Corp., Ill (c,g)
Haynes Stellite Co., Div. of Union Carbide Corp., NY (f)
Hica, Inc., La (g)
Hobbs, Clinton E. Co., Mass (a,b,c)
Howard Foundry Co., Ill (a,b,c,e,f,g)
Investment Casting Co., NJ (a,b,c,f,g)
Ironton Malleable Div., Dayton Malleable Iron Co., Ohio (c)
Jamestown Malleable Iron Corp., NY (c)
Laconia Malleable Iron Corp., NH (c)
Lakeside Malleable Casting Co., Wis (c)
Lebanon Steel Foundry, Pa (g)
Lehigh, Inc., Pa (c)
Liberty Foundry Co., Mo (c,g)
Light Metals Dept., American Brake Shoe Co., NJ (a)
Link-Belt Co., Ill (c)
Loeffler, J.M. Co., Machine & Brass Works, Pa (b)
Lynchburg Foundry Co., Castings Div., Va (c)
Mallory, P.R. & Co., Inc., Ind (b)
Marshall Car Wheel & Foundry Co., Inc., Tex (c)
Massillon Steel Casting Co., Ohio (g)
McCarter Iron Works, Inc., Pa (c,g)
Meehanite Metal Corp., NY
(c)—Ad p 431
Michigan Steel Casting Co., Div. of Consolidated Foundries & Mfg. Corp., Mich (g)
Midwest Foundry Co., Div. of L.A. Darling Co., Mich (c,g)
Misco Precision Casting Co., Mich (c,f, g)
Missouri Diecasting Co., Mo (a,b,c,g)
National Bearing Div., American Brake Shoe Co., Pa (b)
National Lead Construction Co., Inc., Pa (d)
National Malleable & Steel Castings Co., Ohio (c)
Northern Malleable Iron Co., Minn (c)
Ohio Steel Foundry Co., Ohio (f,g)
Oklahoma Steel Casting Div., American Steel & Pump Corp., Okla (g)
Olderman Mfg. Corp., Conn (j)
Olympic Steel Works, Wash (g)
Oregon Brass Works, Ore (a,b)
Oregon Metallurgical Corp., Ore (h)
Pacific Brass Foundry of San Francisco, Calif (a,b,f,j)
Parker, Charles Co., Conn (a,b)
Pelton Steel Casting Co., Wis (f,g)
Perfecto Cast, Calif (f,g)
Pettibone Mulliken Corp., Ill (g)
Pratt & Letchworth Div., Dayton Malleable Iron Co., Inc., NY (g)
Pusey & Jones Corp., Del (c)
Quaker Alloy Casting Co., Pa (c,f,g)
Ridge Foundry, Calif (c)
Rockwell Engineering Co., Ill (a,b,c,g)
Rolle Mfg. Corp., Pa (a,e)
Ross-Meehan Foundries, Tenn (c,g)
Sall Bros. Co., Ill (a,b)
Schilling Bronze Co., NY (a,b,d)
Sorbo-Mat Process Engineers, Mo (c)
Spencer's, I.S. Sons, Inc., Conn (c)
Star Heel Plate Co., Inc., NJ (a,b, c,g)
State Foundry & Machine Co., Wis (c)
Superb Light Alloys, Inc., NY (a,e)
Taylor & Co., Inc., NY (c)
Taylor & Fenn Co., Conn (a,c)
Texas Foundries, Inc., Tex (c,g)
Trenton Brass Co., NJ (b)
True Alloys, Inc., Mich (a,b,d,j)
Unitcast Corp., Ohio (g)
U.S. Magnet & Alloy Corp., NJ (c,f,g)
Uniworld Research Corp. of America, Ohio (c,f)
Utica General Jobbing Foundry, Inc., NY (c)
Utility Steel Foundry, Calif (c,g)
Vanadium-Alloys Steel Co., Pa (g)
Wall Colmonoy Corp., Stainless Process Div., Mich (c,f)
Waterman Industries, Inc., Calif (b,c)
Waukesha Foundry Co., Wis
(a,b,f,g)—Ad p 401
Wayne Agricultural Works, Inc., NC (b,c)
West Steel Casting Co., Ohio (f,g)
Western Automatic Machine Screw Co., Ohio (c)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (a,b,c,f,g,h)
Winters Foundry & Machine Co., Inc., Ohio (a,b,d,f,j)
Woodruff & Edwards, Inc., Ill (c)
Zenith Foundry Co., Wis (c)

Cellophane

(see Cellulose, Regenerated)

Cellulose Acetate

aaRBee Plastic Co., Calif (y)
Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
Albany Novelty Mfg. Co., Mass (t)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,dd,ee)
American Products Mfg. Co., La (t)
Anchor Plastics Co., Inc., NY (bb, dd,ee)
Auburn Plastic Engineering, Ill (bb, cc)
Auburn Plastics, Inc., NY (bb,dd,ee)
Bamberger, Claude P., Inc., NJ (p,y)
Blank, Arthur & Co., Inc., Mass (t, cc)
Cadillac Plastic & Chemical Co., Mich (cc)
Carroll, J.B. Co., Ill (cc)
Celanese Polymer Co., Div., of Celanese Corp. of America, NJ
(p,y)—Ad pp 224-225
Celluplastic Corp., NJ (bb,ee)
Chemical Development Corp., Mass (p)
Chicago Molded Products Corp., Campco Div., Ill (t,cc)
Cleveland Container Co., Ohio (ee)
Coating Products, Inc., NJ (t,cc)
Colonial Kolonite Co., Ill (t,bb,cc, dd,ee)
Comco Plastics, Inc., NY (cc,dd)
Commercial Plastics & Supply Corp., NY (bb,cc,ee)
Craftint Mfg. Co., Ohio (cc)
Crane Plastics, Inc., Ohio (bb,dd,ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (cc)
Davis, Joseph Plastics Co., NJ (t, y,bb,cc,dd,ee)
Denver Plastics, Inc., Colo (u)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
du Pont de Nemours, E.I. & Co., Inc., Del (p,s,t)
Dura Plastics of New York, Inc., NY (cc)
Dyna-Therm Chemical Corp., Calif (p)
Eastman Chemical Products, Inc., Sub. of Eastman Kodak Co., NY (p,y)
Eastman Kodak Co., NY (t,cc)
Eljay Corp., Md (cc)
Fry Plastics International, Calif (t,cc)
General Gasket, Inc., Conn (t,cc)
General Plastics Mfg. Co., Wash (bb,cc,dd,ee)
Gering Plastics, Div. of Studebaker-Packard Corp., NJ (y,bb,dd,ee)
Glass Laboratories, NY (bb,dd,ee)
Gomar Mfg. Co., Inc., NJ (t)
Hall Mfg. Corp., NJ (dd,ee)
Hastings & Co., Inc., Pa (t)
Heyden Newport Chemical Corp., American Plastics Corp. Div., NY (bb,cc,dd,ee)
Industrial Plastics Corp., Ind (bb,dd)
Insulation Mfrs. Corp., Ill (t,cc,dd)
Jet Specialties Co., Inc., Calif (bb, cc,dd,ee)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Knoedler Chemical Co., Pa (bb,cc)
Luminous Resins, Inc., Ill (y)
Lus-Trus Corp., Mich (cc,ee)
Midwest Plastic Products Co., Ill (t,cc)
Monsanto Chemical Co., Plastics Div., Mass (t)
Muehlstein, H. & Co., Inc., NY (y)
National Gasket & Washer Mfg. Co., Inc., NY (cc,dd)
New England Tape Co., Div. of United-Carr Fastener Corp., Mass (bb,cc)
Nixon-Baldwin Chemicals, Inc., NJ (bb,cc,ee)
Norrich Plastics Corp., NY (bb,cc,ee)
Omni Products Corp., NY (y,bb,cc)
Ormond Mfg. Co., Inc., NJ (cc,dd)
Pacific Coast Foil Co., Calif (t)
Panelyte Div., St. Regis Paper Co., NJ (cc)
Perfex Plastics, Inc., (bb,dd,ee)
Philrus Products Co., NJ (cc,dd)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Plast-Ad Mfg. Co., Ind (cc)
Plastic Compounding Corp., Sub. of Plastiglide Mfg. Corp., Calif (y)
Plastic Materials, Inc., NY (y)
Precision Paper Tube Co., Ill (ee)
Pyramid Plastics, Inc., Ill (dd,ee)
Reed Plastics Corp., Mass (y)
Rosco Laboratories, NY (cc)
Rowland Products, Inc., Conn (x,bb, cc,dd,ee)
Russell Mfg. Co., Conn (s)
Schwab Plastic Corp., Mich (x,bb,cc, dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Simon Products Co., Ill (t,cc)
Snyder Mfg. Co., Inc., Ohio (t,cc)
Southern Plastics Co., SC (bb,cc,dd, ee)
Stone Paper Tube Div., Stone Straw Corp., Washington, DC (ee)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., Ill (bb,cc,dd, ee)
Western Felt Works, Ill (cc)
Westlake Plastics Co., Pa (bb,cc,dd, ee)
World Plastics, NY (bb,cc,dd,ee)

Cellulose Acetate Butyrate

aaRBee Plastic Co., Calif (y)
Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
Albany Novelty Mfg. Co., Mass (t,cc)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,dd,ee)
American Molding Powder & Chemical Co., NY (y)
Anchor Plastics Co., Inc., NY (bb,dd, ee)
Anderson Assoc., Inc., Ohio (y)
Anesite Co., Ill (ee)
Auburn Plastic Engineering, Ill (t,bb, cc,ee)
Auburn Plastics, Inc., NY (bb,cc, dd,ee)
Bamberger, Claude P., Inc., NJ (p,y)
Bischoff Chemical Corp., NY (u)

Blank, Arther & Co., Inc., Mass (t,cc)
Busada Mfg. Corp., NY
(ee)—Ad p 415
Cadillac Plastic & Chemical Co., Mich (bb,cc,dd,ee)
Carroll, J.B. Co., Ill (cc)
Celluplastic Corp., NJ (bb,ee)
Chicago Molded Products Corp., Campco Div., Ill (t,cc)
Coating Products, Inc., NJ (t,cc)
Colonial Kolonite Co., Ill (t,bb,cc,ee)
Columbus Coated Fabrics Corp., Ohio (u)
Comco Plastics, Inc., NY (cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,ee)
Crane Plastics, Inc., Ohio (bb,dd,ee)
Crescent Plastics, Inc., Ind (ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Davis, Joseph Plastics Co., NJ (t,y,bb,cc,dd,ee)
Denver Plastics, Inc., Colo (u)
Dewitt Plastics, NY (cc,dd,ee)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Durable Form Products, Inc., NY (cc,ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y)
Eastman Chemical Products, Inc., Sub. of Eastman Kodak Co., NY (p,y)
Eastman Kodak Co., NY (t,cc)
Fidelity Chemical Products Corp., NJ (u)
Fry Plastics International, Calif (t,cc)
General Gasket, Inc., Conn (t,cc)
General Plastics Corp., Ind (cc)
General Plastics Mfg. Co., Wash (bb,cc,dd,ee)
Gering Plastics, Div. of Studebaker-Packard Corp., NJ (y,bb,dd,ee)
Glass Laboratories, NY (bb,dd,ee)
Gomar Mfg. Co., Inc., NJ (t)
Grigoleit Co., Ill (p,s)
Hall Mfg. Corp., NJ (dd,ee)
Heyden Newport Chemical Corp., American Plastics Div., NY (bb,cc,dd,ee)
Hydrawlik Co., NJ (bb,dd)
Industrial Plastics Corp., Ind (bb,dd)
Jet Specialties Co., Inc., Calif (bb,cc,dd,ee)
K S H Plastics, Inc., Mo (bb,cc,dd)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Luminous Resins, Inc., Ill (y)
Lus-Trus Corp., Mich (cc,ee)
Midwest Plastic Products Co., Ill (t,cc)
Muehlstein, H & Co., Inc., NY (y)
New England Tape Co., Div. of United-Carr Fastener Corp., Mass (bb,cc)
Nixon-Baldwin Chemicals, Inc., NJ (bb,cc,ee)
Omni Products Corp., NY (y,bb,cc)
Panelyte Div., St. Regis Paper Co., NJ (cc)
Perfex Plastics, Inc., Ill (bb,dd,ee)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Plastic Compounding Corp., Sub. of Plastiglide Mfg. Corp., Calif (y)
Precision Paper Tube Co., Ill (ee)
Pyramid Plastics, Inc., Ill (dd,ee)
Rowland Products, Inc., Conn (x,bb,cc,dd,ee)
Schwab Plastic Corp., Mich (x,bb,cc,dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Snyder Mfg. Co., Inc., Ohio (t,cc)
Southern Plastics Co., SC (bb,cc,dd,ee)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., Ill (bb,cc,dd,ee)
Western Felt Works, Ill (cc)
Western Plastics Corp., Neb (bb,dd,ee)
Westlake Plastics Co., Pa (bb,cc,dd,ee)
World Plastics, NY (bb,cc,dd,ee)

Cellulose Nitrate

Adhesive Products Corp., NY (x)
Chemical Development Corp., Mass (p)
Columbus Coated Fabrics Corp., Ohio (u)
du Pont de Nemours, E.I. & Co., Inc., Del (p)
General Gasket, Inc., Conn (t)
Hercules Powder Co., Inc., Del (p)
Kaufman Glass Co., Del (cc)
Nixon-Baldwin Chemicals, Inc., NJ (bb,cc,ee)
Omni Products Corp., NY (bb,cc)
Panelyte Div., St. Regis Paper Co., NJ (cc)
Rowland Products, Inc., Conn (x,cc)
Wasco Products, Inc., Mass (cc)
Western Felt Works, Ill (cc)

Cellulose Propionate

aaRBee Plastic Co., Calif (y)
Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,ee)
Anchor Plastics Co., Inc., NY (bb,dd,ee)
Anderson Assoc., Inc., Ohio (y)
Celanese Polymer Co., Div. of Celanese Corp. of America, NJ
(p,y)—Ad pp 224-225
Eastman Chemical Products, Inc., Sub. of Eastman Kodak Co., NY (p,y)
Gering Plastics Div., Studebaker-Packard Corp., NJ (y)
Glass Laboratories Inc., NY (bb,dd,ee)
Perfex Plastic, Inc., Ill (bb,dd)
Scranton Plastic Laminating Corp., Pa (cc)
Southern Plastics Co., SC (bb,cc,dd,ee)
Superior Plastics, Inc., Ill (ee)
World Plastics, NY (bb,cc,dd,ee)

Cellulose, Regenerated

(e.g., Cellophane)
Adhesive Products Corp., NY (x)
American Viscose Corp., Pa
(s,t)—Ad p 309
Blank, Arthur & Co., Inc., Mass (t)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
du Pont de Nemours, E.I. & Co., Inc., Del (s,t,cc)
Dura-Lee Corp., Kan (t)
Foss Mfg. Co., Id (t)
Kaufman Glass Co., Del (cc)
Mason Envelope Co., Inc., NY (t)
Olin Mathieson Chemical Corp., Packaging Div., NY (t)
Pacific Coast Foil Co., Calif (t)

Cemented Carbides

(see Cermets)

Centrifugal Castings

(see Castings)

Ceramic Coatings

(see Inorganic Coatings)

Ceramics, Alumina

Alite Div., U.S. Stoneware Co., Ohio (r)
Aluminum Co. of America, Pa
American Lava Corp., Tenn (r,z,bb,ee)
Baker, J. T. Chemical Co., NJ (aa)
Brunswick Corp., Va (r,u)
CFI Corp., NY (r,bb,ee)
Carborundum Co., NY (r,z,aa,bb,ee)
Carborundum Co., Refractories Div., NJ (r,s,z,aa,bb,cc,ee)
Centralab Electronics Div., Globe Union, Inc., Wis
(r,bb,ee)—Ad p 402
Continental Coatings Corp., Ohio (aa)
Coors Porcelain Co., Colo (r,bb,ee)
Corning Glass Works, NY (r)
Diamonite Products Mfg. Co., Ohio (o,r,z,bb,cc,ee)
Du-Co Ceramics Co., Pa (r,bb,ee)
Electric Autolite Co., Ceramic Div., Ohio (r,u,z,bb,ee)
Electro-Ceramics, Inc., Utah (r,z,bb,cc,ee)
Electro Refractories & Abrasives Corp., NY (r)
Engineered Ceramics Mfg. Co., Ill (r,z,bb,ee)
Frenchtown Porcelain Co., NJ (r,bb,cc,ee)
Gladding, McBean & Co., Technical Ceramic Div., Calif (r,u,z,bb,cc,ee)
Gulton Industries, Inc., NJ (r,aa,bb,ee)
Industrial Sapphire Co., Pa (r)
Louthan Mfg. Div., Ferro Corp., Ohio (z)
Mansol Ceramics Co., NJ (r)
McDanel Refractory Porcelain Co., Pa
(r,bb,cc,ee)—Ad p 315
Metallizing Co. of Los Angeles, Inc., Calif (r,bb)
Metco Inc., NY (aa)
Monsanto Chemical Co., Inorganic Chemicals Div., Mo (aa)
Morganite Inc., NY (r,z,aa,bb,ee)
National Beryllia Corp., NJ (r,z,bb,cc,ee)
Norton Co., Mass (r,z,aa,bb,ee)
Nuclear Materials & Equipment Corp., Pa (r,aa)
Plasmadyne Corp., Calif (aa)
Plasmatech Div., Valley Metallurgical Processing Co., Conn (r,aa)
Pyrosil, Inc., Ohio (r)
Saxonburg Ceramics, Inc., Pa
(r,z,bb,cc,ee)—Ad p 312
U.S. Stoneware Co., Ohio (r)
Wellsville Fire Brick Co., Mo (r)
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif (r,z,aa,bb,cc,ee)
Zeller Corp., Ohio
Zirconium Corp. of America, Ohio (r,z,bb,ee)

Ceramics, Corundum

Carborundum Co., NY (r,z,bb,ee)
Centralab Electronics Div., Globe Union, Inc., Wis (r,bb,ee)
Electrical Refractories Co., Ohio (r)
Electro-Ceramics, Inc., Utah (r,z,bb,cc,ee)
Engineered Ceramics Mfg. Co., Ill (r,z,bb,ee)
Industrial Sapphire Co., Pa (r)
Metco Inc., NY (aa)
Morganite Inc., NY (r,z,bb,ee)

Ceramics, Forsterite

American Lava Corp., Tenn (r,z,bb,ee)
CFI Corp., NY (r,bb,ee)
Centralab Electronics Div., Globe Union, Inc., Wis (r,bb,ee)
Corning Glass Works, NY (r)
Du-Co Ceramics Co., Pa (r,bb,ee)
General Ceramics Div., Indiana General Corp., NJ (r, bb, ee)
Gladding, McBean & Co., Technical Ceramic Div., Calif (r,z,bb,cc,ee)
Saxonburg Ceramics, Inc., Pa
(r,z,bb,ee)—Ad p 312

Ceramics, Rare Earth

Centralab Electronics Div., Globe Union, Inc., Wis (r,bb,ee)
Continental Coatings Corp., Ohio (aa)
Electric Autolite Co., Ohio (r)
Engineered Ceramics Mfg. Co., Ill (r,z,bb,ee)
General Astrometals Corp., NY (r,s,aa,bb,cc,ee)
Metco, Inc., NY (aa)
National Beryllia Corp., NJ (r,z,bb,cc,ee)
Nuclear Materials & Equipment Corp., Pa (r,aa)
Nuclear Metals, Inc., Mass (r)
Research Chemicals Div., Nuclear Corp. of America, Calif (aa,bb)
Zirconium Corp. of America, Ohio (r,z,aa,bb,ee)

Ceramics, Steatite

American Lava Corp., Tenn (r,z,bb,ee)
CFI Corp., NY (r,bb,ee)
Carborundum Co., NY (r,z,bb,ee)
Carborundum Co., Refractories Div., NJ (r,z,bb,ee)
Centralab Electronics Div., Globe Union, Inc., Wis
(r,bb,ee)—Ad p 402
Du-Co Ceramics Co., Pa (r,bb,ee)
Electro-Ceramics, Inc., Utah (r,z,bb,cc,ee)
Gladding, McBean & Co., Technical Ceramic Div., Calif (r,z,bb,cc,ee)
Industrial Sapphire Co., Pa (r)
Louthan Mfg. Div., Ferro Corp., Ohio (r,ee)
Mansol Ceramics Co., NJ (r)
Saxonburg Ceramics, Inc., Pa
(r,z,bb,ee)—Ad p 312
Star Porcelain Co., NJ (r,z,bb,cc,ee)
Steward, D. M. Mfg. Co., Tenn (r,z,bb,ee)
Wisconsin Porcelain Co., Wis (r,bb,cc,ee)

KEY

MATERIALS

a—Aluminum and its alloys	e—Magnesium and its alloys	j—Zinc and its alloys
b—Copper and its alloys	f—Nickel and its alloys	k—Thermoplastics
c—Iron and its alloys (except steel)	g—Steels	l—Thermosetting plastics
d—Lead and its alloys	h—Titanium and its alloys	m—Elastomers

BASIC FORMS

n—Anodes	r—Custom formed parts (incl. specialties)	v—Foil	aa—Powder
o—Bar	s—Fibers	w—Ingot	bb—Rod
p—Base resins, polymers or gums	t—Film	x—Laminating, casting resins	cc—Sheet
q—Billets	u—Foams (component materials or products)	y—Molding compounds	dd—Strip
		z—Plate	ee—Tubing
			ff—Wire

Ceramics, Whiteware

Carborundum Co., NY (r,z,bb,ee)
Centralab Electronics Div., Globe Union, Inc., Wis (r,bb,ee)
Du-Co Ceramics Co., Pa (r,bb,ee)
Electro-Ceramics, Inc., Utah (r,z,bb,cc,ee)
Frenchtown Porcelain Co., NJ (r,bb,cc,ee)
General Ceramics Div., Indiana General Corp., NJ (r, bb, ee)
Gladding, McBean & Co., Technical Ceramic Div., Calif (r,z,bb,cc,ee)
Knight, Maurice A. Co., Ohio (r,ee)
Saxonburg Ceramics, Inc., Pa (r,z,bb,ee)
Star Porcelain Co., NJ (r,z,bb,cc,ee)
Steward, D. M. Mfg. Co., Tenn (r,z,bb,ee)
Wisconsin Porcelain Co., Wis (r,bb,cc,ee)

Ceramics, Other

Akron Porcelain Co., Ohio (r)
American Lava Corp., Tenn (r,z,bb,ee)
Amersil Quartz Div., Engelhard Industries, Inc., NJ (r,s,z,aa,bb,cc,ee)
Arnold Engineering Co., Ill (r)
Avins Industrial Products Corp., NY (ee)
Beryl Ores Co., Colo (aa,cc)
Brunswick Corp., Va (r,u)
Brush Beryllium Co., Ohio (r,z,aa,bb,ee)
Carborundum Co., NY (r,s,u,z,aa,bb,ee)
Carborundum Co., Refractories Div., NJ (r,z,aa,bb,cc,ee)
Centralab Electronics Div., Globe Union, Inc., Wis (r,bb,ee)—Ad p 402
Continental Coatings Corp., Ohio (aa)
Coors Porcelain Co., Colo (r,bb,ee)
Corning Glass Works, NY (r)
Electric Autolite Co., Ohio (r)
Electrical Refractories Co., Ohio (r,ee)
Electro Refractories & Abrasives Corp., NY (r)
Electro-Ceramics, Inc., Utah (r,z,bb,cc,ee)
Emerson & Cuming, Inc., Mass (u,aa,cc)
Engineered Ceramics Mfg. Co., Ill (r,z,bb,ee)
Ferroxcube Corp. of America, NY (r,bb)
Frenchtown Porcelain Co., NJ (r,bb,cc,ee)
General Electric Co., Chemical Materials Dept., Mass
Gladding, McBean & Co., Technical Ceramic Div., Calif (r,z,bb,cc,ee)
Gulton Industries, Inc., NJ (aa)
Knight, Maurice A. Co., Ohio (r,ee)
Laboratory Equipment Corp., Mich (r,z,bb,cc,ee)
Louthan Mfg. Div., Ferro Corp., Ohio (r,z,bb,ee)
Malvern Brick & Tile Co., Ark (r)
Mansol Ceramics Co., NJ (r)
McDanel Refractory Porcelain Co., Pa (r,bb,cc,ee)—Ad p 315
Metal & Thermit Corp., NJ (aa)
Metallizing Co. of Los Angeles, Inc., Calif (r,bb)
Metco, Inc., NY (aa)
Molecular Dielectrics, Inc., NJ (r,u,z,bb,cc)
Monsanto Chemical Co., Inorganic Chemicals Div., Mo (aa)
Mycalex Corp. of America, NJ (r,z,aa,bb,cc,ee)—Ad p 320
National Beryllia Corp., NJ (r,z,bb,cc,ee)
Nuclear Materials & Equipment Corp., Pa (r,aa)
Nuclear Metals, Inc., Mass (r)
Pfaudler Co., NY
Plasmadyne Corp., Calif (aa)
Plasmatech Div., Valley Metallurgical Processing Co., Conn (r,aa)
Porcelain Products Co., Ohio (r)
Pyrosil, Inc., Ohio (r,z,aa,bb,cc,ee)
Refractory Specialties Co., Pa (r)
Saxonburg Ceramics, Inc., Pa (r,z,bb,ee)—Ad p 312
Star Porcelain Co., NJ (r,z,bb,cc,ee)
Steward, D. M. Mfg. Co., Tenn (r,z,bb,ee)
Taunton Div., Haveg Industries, Inc., Mass (r)
Thompson, H. I. Fiberglass Co., Calif (s)
U.S. Stoneware Co., Ohio (r)
Wellsville Fire Brick Co., Mo (r,aa)
Wisconsin Porcelain Co., Wis (r,bb,cc,ee)
Zirconium Corp. of America, Ohio (r,z,aa,bb,ee)

Cermets

Allegheny Ludlum Steel Corp., Pa (r)
American Brakeblok Div., American Brake Shoe Co., Mich (r)
American Lava Corp., Tenn (r,z,bb,ee)
American Sinteel Corp., NY (r)
Brush Beryllium Co., Ohio (r,aa)
Carborundum Co., NY (r)
Continental Coatings Corp., Ohio (aa)
Emerson & Cuming, Inc., Mass (r,u)
Firth Sterling, Inc., Pa (r)
General Electric Co., Metallurgical Products Dept., Mich (r)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (r,u,aa)
Haynes Stellite Co., Div. of Union Carbide Corp., NY (r)
Hommel, O. Co., Pa (aa)
Kanthal Corp., Conn (bb)
Kennametal, Inc., Pa (r,aa,bb,ee)—Ad p 323
Metal Carbides Corp., Ohio (r)
Metallizing Co. of Los Angeles, Inc., Calif (bb)
Metco, Inc., NY (aa)
National Beryllia Corp., NJ (r,z,bb,cc,ee)
Nuclear Metals, Inc., Mass (r,bb,cc,ee)
Plasmadyne Corp., Calif (aa)
St. Eloi Corp., Ohio (r,z,aa)
Sintercast Div., Chromalloy Corp., NY (r)
Stackpole Carbon Co., Pa (r)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (r,aa)
Universal Dynamics Div., Acoustica Associates, Inc., Calif (r,bb,ee)
U.S. Stoneware Co., Ohio (r)
Wall Colmonoy Corp., Mich (aa,bb,r)

Chemical Conversion Coatings

(see Conversion Coatings)

Chlorinated Polyether

Argo Plastic Products Co., Ohio (cc,dd)
General Plastics Corp., NJ (t)
Hercules Powder Co., Inc., Del (y)
National Vulcanized Fibre Co., Del (bb,cc,ee)
Polymer Corp., Pa (t,bb,cc,dd,ee)—Ad p 264
Toyad Corp., Pa (u)

Chloroprene Rubber

(Neoprene)

Adhesive Products Corp., NY (x)
American Rubber Products Corp., Ind (u,bb,cc,dd,ee)
Atlas Mineral Products Co., Pa (cc)
Auburn Rubber Co., Inc., Ind (cc)
Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Bond International, Inc., Mich (y,ee)
Broadway Rubber Corp., Ky (u,cc)
Brown Rubber Co., Inc., Ind (u)
Buffalo Weaving & Belting Co., NY (cc)
Capac Mfg. Corp., Mich (y,cc)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chemical Coatings & Engineering Co., Inc., Pa (x,y)
Chicago Rubber Co., Inc., Ill (u,y)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio (y,cc,dd—Ad p 416
Continental Rubber Works, Pa (bb,cc,dd,ee)
Coyne & Paddock, Inc., NY (cc)
Dayton Rubber Co., Ohio (y,bb,cc,dd,ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E.I. & Co., Inc., Del (p)
Dutch Brand Div., Johns-Manville Corp., Ill (u,y,cc,dd)
Dyna-Therm Chemical Corp., Calif (p)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Faultless Rubber Co., Ohio (u,y,bb,ee)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (s,u,y,cc,ee)
Flexfirm Products, Calif (s)
Flexible Tubing Corp., Conn (ee)
Foamade Industries, Mich (u)
Garlock Packing Co., NY (y,bb,cc,dd,ee)
Geauga Industries Co., Ohio (y,bb,dd)
Goodrich, B.F. Co., Conn (u)
Goshen Rubber Co., Inc., Ind (y)
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd,ee)
Knight, Maurice A. Co., Ohio (cc)
Maloney, F.H. Co., Tex (y)
Martin Rubber Co., Inc., NJ (y,dd,ee)
Mid-States Rubber Products, Inc., Ind (y)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (x)
Paeco Rubber Co., Inc., Ohio (y,dd,ee)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (y)
Parker, Stearns & Co., Inc., NY (y,bb,cc,dd,ee)
Pawling Rubber Corp., NY (bb,dd,ee)
Polymer Chemical Co., Ohio (x)
Prince Rubber & Plastics Co., Inc., NY (bb,cc,ee)
Raybestos-Manhattan, Inc., Plastics Products Div., Pa (x)
Rayclad Tubes, Inc., Calif (ee)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p,y,cc,dd,ee)
Roberts Toledo Rubber Co., Ohio (ee)
Rogers Corp., Conn (u,y,cc,dd)
Roth Rubber Co., Ill (y,cc)
Rubatex Div., Great American Industries, Inc., Va (u)
Russell Mfg. Co. Conn (ee)
Sheller Mfg. Corp., Mich (u)
Snyder, M.L. & Son, Inc., Pa (cc,ee)
Sperry Rubber & Plastics Co., Ind. (dd,ee)
Standard Products Co., Mich (y)
Stockwell Rubber Co., Inc., Pa (u,y,bb,cc,dd)
Technical Specialties Co., NY (dd)
Toyad Corp., Pa (u)
Trostel, Albert Packing Ltd., Wis (y)
U.S. Rubber Co., Kem-Blo Dept., Conn (u)
U.S. Stoneware Co., Ohio (y)
Vulcan Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Chlorosulfonated Polyethylene Rubber

Adhesive Products Corp., NY (x)
Atlas Mineral Products Co., Pa (cc)
Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Bond International, Inc., Mich (y,ee)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chemical Coatings & Engineering Co., Inc., Pa (x,y)
Chicago-Allis Mfg. Corp., Ill (p)
Colonial Rubber Corp., Ohio (y,cc)—Ad p 416
Continental Rubber Works, Pa (bb,cc,dd,ee)
Dayton Rubber Co., Ohio (y,bb,cc,dd,ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E. I. & Co., Inc., Del (p)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (y,cc,ee)
Flexfirm Products, Calif (s)
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd,ee)
Maloney, F.H. Co., Tex (y)
Paeco Rubber Co., Inc., Ohio (y,dd,ee)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (y)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Prince Rubber & Plastics Co., Inc., NY (cc,ee)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p)
Roberts Toledo Rubber Co., Ohio (ee)
Rogers Corp., Conn (cc,dd)
Roth Rubber Co., Ill (y,cc)
Sperry Rubber & Plastics Co., Ind (dd,ee)
Stockwell Rubber Co., Inc., Pa (cc)
Swan Rubber Co., Ohio (ee)
Toyad Corp., Pa (t,u)
Trostel, Albert Packing, Ltd., Wis (y)
Vulcan Div., Reeves Bros., Inc., NY (p,y,cc)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Chlorotrifluoroethylene

(see Fluorocarbon)

Chromate Coatings

(see Conversion Coatings)

Chromium

Alloy Metal Powder, Inc., Iowa (aa)
Alloy Metal Products, Inc., Iowa (o,w)
American Nickel Alloy Mfg. Corp., NY (w,aa)
Arcos Corp., Pa (ff)
Belmont Smelting & Refining Works, Inc., NY (w,aa)
Chicago Development Corp., Md (aa)
Foote Mineral Co., Pa (aa)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (aa)
Hull, R.O. & Co., Inc., Ohio (n)
K. & L. Plating Co., Pa (z)
Kawecki Chemical Co., NY (aa)
Lakeland Industries, Minn (z)
Metal Hydrides, Inc., Mass (aa)
Metal & Thermit Corp., NJ (w)
Metals Disintegrating Co. Div., American-Marietta Co., NJ (aa)
Michigan Seamless Tube Co., Mich (ee)
Modern Plating Corp., Ill (n)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Nuclear Metals, Inc., Mass (w,bb,dd,ee)
Plasmadyne Corp., Calif (aa)
Republic Steel Corp., Steel & Tubes Div., Ohio (ee)
Sel-Rex Corp., NJ (n)
Shieldalloy Corp., NJ (aa)
Stevens, Frederic B., Inc., Mich (n)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Vanadium Corp. of America, NY (w)
Walmet Alloys Co., Mich (w)

Chromized Coatings

(see Diffusion Coatings)

Clad Metals

(key letters refer to base metals; see also Laminates, Metal-Metal)

Alabama Wire Co., Inc., Ala (a)
Allegheny Ludlum Steel Corp., Pa (g)
Aluminum Co. of America, Pa (a)
American Silver Co., NY (b,c,f,g)
Arrow Metal Products Corp., NJ (a)
Bart Mfg. Corp., NJ (a,b,c,e,f,g,h)
Bartlett-Thompson Co., Inc., Mass (a, b,f)
Bishop, J. & Co. Platinum Works, Pa
(f,g,h)—Ad p 394
Borg-Warner Corp., Ill (g)
Bridgeport Brass Co., Conn (b,f,g,h)
Chicago Bridge & Iron Co., Ill (g)
Chicago Development Corp., Md (h)
Composite Industrial Metals, Inc., RI (a,b,c,d,e,f,g,h,j)
Copper & Brass Sales, Inc., Mich (a)
Copperweld Steel Co., Pa (g)
Darby Corp., Kan (a,f,g)
Delco Moraine Div., General Motors Corp., Ohio (a,d)
Driver-Harris Co., NJ (f)
Electric Materials Co., Pa (c)
Electronic Parts Mfg. Co., Inc., NJ (b,f)
Enamel Products Co., Ohio (a,g)
Esco Corp., Ore (f,g)
Fromson Orban Co., Inc., NY (b,f,g)
General Alloys Co., Mass (f,g)
General Finding & Supply Co., Industrial Div., Mass
(b)—Ad p 368
Gibson Electric Sales Corp., Pa
(a,b,c,f,g,h,j)—Ad p 408
Horton-Angell Co., Mass (b,f)
Improved Seamless Wire Co., RI (b,f)
Jessop Steel Co., Pa (g)
Johnson Bronze Co., Pa (a,b,d,g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kassel Export Co., Inc., NJ (b,c,g)
Knapp Mills Inc., NY (a,b,d,g)
Leach & Garner Co., Industrial Div., Mass (b,f)
Lukens Steel Co., Pa (a,b,e,f,g,h)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (b,c,f,g)
Manufacturers & Fabricators, Inc., Ohio (f,g)
Metal Goods Corp., Mo (f)
National Galvanizing Co., Pa (g)
National Lead Co., NY (d)
National Lead Construction Co., Inc., Pa (d)
National-Standard Co., Mich (a,b,d,f,j)
Nuclear Metals, Inc., Mass (a,b,c,e, f,g,h)
Olin Mathieson Chemical Corp., Metals Div., NY (a)
Parish Pressed Steel Div., Dana Corp., Pa (a,g,j)
Phoenix Steel Corp., NY (g)
Presswork, Inc., Mich (b,d)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (a,b)
Reynolds Metals Co., Va (a)
Riverside-Alloy Metal Div., H.K. Porter Co., Inc., NJ (b,f)
Rockwell Engineering Co., Ill (a,b, c,g)
Ryerson, Joseph T. & Son, Inc., Ill (a)
Saginaw Bearing Co., Mich (b,g)
Sandy Hill Iron & Brass Works, NY (g)
Seattle Boiler Works, Inc., Wash (g)
Sheldon, M.L. & Co., Inc., NY (f)
Simoniz Products Div., Simoniz Co., Ill (a,g)
Somers Brass Co., Inc., Conn (f)
Standard Metals Corp., Mass (a,b,c, f,g)
Sun Steel Co., Ill (a,e,g)
Superior Steel Div., Copperweld Steel Co., Pa (g)
Sylvania Electric Products, Inc., Parts Div., Pa (b,g)
Texas Instruments, Inc., Metals & Controls Div., Mass
(a,b,c,f,g,h)—Ad p 366
Tickle, Arthur Engineering Works, Inc., NY (c,f,g,h)
Vacuum Technology, Inc., Calif (h)
Werner, R.D. Co., Pa (a,g)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (f,g,h)
Whitehead Metal Products Co., Inc., NY (f)
Worcester Wire Works Div., National-Standard Co., Mass (g)

Claddings

(see Organic Coatings; Clad Metals)

Coated Metals

(see Precoated Metals)

Coatings

(see Electroplated, Organic, etc.)

Cobalt and Its Alloys

African Metals Corp., NY (aa)
Alloy Metal Products, Inc., Iowa (o, w)
American Nickel Alloy Mfg. Corp., NY (w,aa)
Austenal Co., Div. of Howe Sound Co., NY (w)
Belmont Smelting & Refining Works Inc., NY (n,w,aa)
Cannon-Muskegon Corp., Mich (w)
Coast Metals, Inc., NJ (bb)
Crucible Steel Co. of America, Pa (o,q,w,z,cc,dd)
Driver, Wilbur B. Co., NJ (v,bb,dd, ff)
Driver-Harris Co., NJ (bb,dd)
Dudek & Bock Spring Mfg. Co., Ill (ff)
Elgin National Watch Co., Abrasives Div., Ill (o,bb,dd,ff)
Foote Mineral Co., Pa (aa)
General Electric Co., Metallurgical Products Dept., Mich (q,w,aa,bb,cc, dd)
Hamilton Watch Co., Precision Metals Div., Pa (v,w,bb,cc,dd)
Hardy, Charles, Inc., NY (aa)
Haynes Stellite Co., Div. of Union Carbide Corp., NY (o,q,v,w,z,bb,cc, dd,ee,ff)
Hoskins Mfg. Co., Mich (bb,dd)
K. & L. Plating Co., Pa (z)
Kelsey-Hayes Co., Metals Div., NY (o,q,v,w,z,bb,cc,dd,ff)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o)
McGean Chemical Co., Ohio (aa)
Metal Hydrides, Inc., Mass (aa)
Michigan Seamless Tube Co., Mich (ee)
New Jersey Metals Co., NJ (w)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Nuclear Metals, Inc. Mass (w)
Plasmadyne Corp., Calif (aa)
Sherritt Gordon Mines Ltd., Canada (aa)
Sierra Metals Corp., Sub. of American-Marietta Co., Ill (w)
Temescal Metallurgical Corp., Calif (o,q,w,z)
Texas Instruments, Inc., Metals & Controls Div., Mass (v,dd)
Trent Tube Co., Pa (ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Universal-Cyclops Steel Corp., Pa (o, q,z,bb,cc,ff)
Vanadium-Alloys Steel Co., Pa (aa, ee)
Walmet Alloys Co., Mich (w)
Wall Colmonoy Corp., Mich (w,bb)
Wallingford Steel Co., Conn (dd,ee)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd, ee)

Cold Extrusions

(see Impact Extrusions)

Cold Headed Parts

Abbott Ball Co., Conn (b,g)
Albany Products Co., Inc., Conn (a, b,f)
Allied Products Corp., Mich (g)
Allmetal Screw Products Co., Inc., NY (f,g,h)
Aluminum Co. of America, Pa (a)
American Car & Foundry Div., ACF Industries, Inc., NY (g)
Ampco Metal, Inc., Wis (b)
Anti-Corrosive Metal Products Co., Inc., NY (g)
Armco Steel Corp., Sheffield Div., Mo (g)
Art Wire & Stamping Co., NJ (a,b,c, d,f,g)
Bead Chain Mfg. Co., Conn (a,g)
Bethlehem Steel Co., Pa (g)
Camcar Screw & Mfg. Co., Ill (a,g,h)
Central Screw Co., Ill (a,b,c,f,g)
Champion Rivet Co., Ohio (c,g)
Chandler Products Corp., Ohio (g)
Chicago Rivet & Machine Co., Ill (a, c,g)
Chicago Screw Co., Div. of Standard Screw Co., Ill (a,b,c,f,g)
Clark Bros. Bolt Co., Conn (a,b,c,g)
Clendenin Bros., Inc., Md (a,b,c)
Cleveland Cap Screw Co., Ohio (a, b,f,g,h)
Columbus Bolt & Forging Co., Ohio (a,b,g)
Deringer Metallurgical Corp., Ill (a, b,c,d,f,g)
Division Lead Co., Ill (d)
Eaton Mfg. Co., Reliance Div., Ohio (a,g)
Elco Tool & Screw Corp., Ill (a,b,c,g)
Electric Materials Co., Pa (b)
General Chain & Mfg. Corp., Ohio (g)
General Findings & Supply Co., Industrial Div., Mass (b,f)
Gibson Electric Sales Corp., Pa (f)
Greene, G.G. Corp., Pa (g)
Grip Nut Co., Sub. of Heli-Coil Corp., Ind (a,b,g)
Harper, H. M. Co., Ill (a,b,f,h)
Hartford Machine Screw Co., Div. of Standard Screw Co., Conn (a,b,c,f,g)
Hassall, John, Inc., NY (a,b,c,d,f,g)
Hercules Fastener Co., Ill (a,b,c,g,j)
Huck Mfg. Co., Mich (a,g)
Hunter Corp., Pa (a,b,c,f,g,h)
Jaques Co., Mass (a,b,e,f,g,h)
Johnston & Funk Titanium Corp., Ohio (h)
Koehler Mfg. Co., Mass (c)
Lamson & Sessions Co., Ohio (a,b,c,f, g,h)
Maynard Mfg. Co., Mich (a,b,f,g)
McKinney Mfg. Co., Pa (a,b,c,f,g)
Mid-West Screw Products Co., Mo (a, b,c,g)
Milford Rivet & Machine Co., Conn (a,b,c,g)
Midland Screw Corp., Ill (a,b,c,d,e, f,g,j)
Murray Tube Works, Inc., NJ (a,b,j)
National Lock Co., Ill (a,b,c,d,g)
National Lock Co., Fastener Div., Ill (a,b,c,g)
National Screw & Mfg. Co., Ohio (a,b, f,g)
Parish Pressed Steel Div., Dana Corp., Pa (g)
Pheoll Mfg. Co., Inc., Ill (a,b,c,g)
Plume & Atwood Mfg. Co., Conn, (a, b,g)
Pusey & Jones Corp., Del (c)
Reed & Prince Mfg. Co., Mass (a, b,f,g)
Republic Steel Corp., Ohio (g)
Rockwell Engineering Co., Ill (a,b,c, g)
Rome Mfg. Div., Revere Copper & Brass, Inc., NY (a,b)
Russell, Burdsall & Ward Bolt & Nut Co., NY (a,b,g)
Scovill Mfg. Co., Mill Products Div., Conn (a,b)
Shakeproof Div., Illinois Tool Works, Ill (a,b,g)
Standard Pressed Steel Co., Pa (a,b, f,g,h)
Thompson-Bremer & Co., Ill (a,b,c,f, g,h)
Torrington Co., Conn (a,b,f,g)
Townsend Co., Engineered Fasteners Div., Pa (a,b,g)
Tubular Rivet & Stud Co., Mass (a, b,c,f,g)
Union Screw & Mfg. Co., Pa (a,g)
United Screw & Bolt Corp., Ill (a,b,g)
United-Carr Fastener Corp., Mass (b,g)
Universal Screw Co., Ill (a,b,f,g,h)
Weatherhead Co., Ind (g)
Wesbar Stamping Corp., Wis (a,c,g)
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (a,b,c,f,g)
Zeller Corp., Ohio (g)

Columbium and Its Alloys

American Silver Co., NY (v,dd,ee,ff)
Bishop, J. & Co. Platinum Works, Pa (ee)
Damascus Tube Co., Pa (ee)
du Pont de Nemours, E. I. & Co., Inc., Del (w)
Fansteel Metallurgical Corp., Ill
(n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)—Ad pp 161-164

KEY

MATERIALS

a—Aluminum and its alloys	e—Magnesium and its alloys	j—Zinc and its alloys
b—Copper and its alloys	f—Nickel and its alloys	k—Thermoplastics
c—Iron and its alloys (except steel)	g—Steels	l—Thermosetting plastics
d—Lead and its alloys	h—Titanium and its alloys	m—Elastomers

BASIC FORMS

n—Anodes	r—Custom formed parts (incl. specialties)	v—Foil	aa—Powder
o—Bar	s—Fibers	w—Ingot	bb—Rod
p—Base resins, polymers or gums	t—Film	x—Laminating, casting resins	cc—Sheet
q—Billets	u—Foams (component materials or products)	y—Molding compounds	dd—Strip
		z—Plate	ee—Tubing
			ff—Wire

Hamilton Watch Co., Precision Metals Div., Pa (v,dd)
Hardy, Charles, Inc., NY (aa)
Harvey Aluminum, Calif (o,ee,ff)
Hoskins Mfg. Co., Mich (ff)
Johnston & Funk Titanium Corp., Ohio (bb,ff)
Kawecki Chemical Co., NY (o,q,v,w,z, aa,bb,cc,dd,ff)
Kennametal, Inc., Pa
(o,v,aa,dd)—Ad p 323
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,bb,dd,ee)
Meier Brass & Aluminum Co., Mich (o,z,bb,cc,dd,ee,ff)
Molybdenum Corp. of America, Pa
Nuclear Metals, Inc., Mass (w,bb,dd, ee)
Oregon Metallurgical Corp., Ore (w)
Plasmadyne Corp., Calif (aa)
Rodney Metals, Inc., Mass (v,dd)
Shieldalloy Corp., NJ (o,w,aa)
Superior Tube Co., Ill
(ee)—Ad pp 424-425
Techalloy Co., Inc., Pa (dd,ff)
Temescal Metallurgical Corp., Calif
(o,q,w,z)—Ad p 167
Texas Instruments, Inc., Metals & Controls Div., Mass (v,dd)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (w,aa)
United Screw & Bolt Corp., Ill (bb,cc, dd,ff)
Universal-Cyclops Steel Corp., Pa (o, q,z,cc)
Vanadium Corp. of America, NY (w)
Wah Chang Corp., NY
(n,v,w,aa,bb,dd,ff)—Ad p 152
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd, ee)
Wolverine Tube Div., Calumet & Hecla, Inc., Mich (ee)

Composition Board
(see Wood)

Compression Moldings
(see Moldings)

Conversion Coatings, Anodic
(anodizers)

Abalon Precision Mfg. Corp., NY
Abco Aluminum & Brass Works, Tex
Accurate Anodizing Corp., Ill
Acme Plating Co., Ohio
Aerolite Extrusion Co., Ohio
Alchemize Corp., Ill
Aluminum Billets, Inc., Ohio
Aluminum Finishing Corp., Ind
Aluminum Specialty Co., Wis
American Emblem Co., Inc., NY
Auld, D.L. Co., Ohio
B & T Metals Co., Ohio
Badger Aluminum Extrusions, NY
Biddle Screw Products Co., Ind
Bonnell, William L. Co., Inc., Ga
Briggs-Shaffner Co., NC
Brinkerhoff Brass & Bronze Works, Inc., NY
Brown Lipe Chapin Div., General Motors Corp., NY
Brooks & Perkins, Inc., Mich
Chicago Hardware Foundry Co., Ill
Chicago Thrift-Etching Corp., Ill
Coil Anodizers, Inc., Mich
Colonial Alloys Co., Pa
Commercial Screw Products Co., Ohio
Corson Industries, Pa
Cowles Chemical Co., Ohio
Croname, Inc., Ill
Designers Metal Corp., Ill
Diversey Corp., Metal Industries Div., Ill
Doehler-Jarvis Div., National Lead Co., Ohio
Dollin Corp., NJ
Edna Lite Optical Co., Inc., NY
Engineering Products & Specialties, Inc., RI
Fox Co., Ohio
General Extrusions, Inc., Ohio
Hamilton Die Cast, Inc., Ohio
Himmel Bros. Co., Conn
Hull, R.O. & Co., Inc., Ohio
Industrial Chromium Corp., Mass
Jarl Extrusions, Inc., NY
Jervis Corp., Mich
Kawneer Co., Mich
Kees, F.D., Mfg. Co., Neb
Kinkead Industries, Inc., Ill
Leed, H.A. Corp., Conn
Magnesium Elektron, Inc., NY
May, Inc., Tex
Merz Machine & Tool Works, Ind
Metal Finishers, Inc., Md
Mirro Aluminum Co., Wis
Modern Plating Corp., Ill
National Aluminum Co., Ohio
National Galvanizing Co., Pa
National Gasket & Washer Mfg. Co., Inc., NY
National Lock Co., Ill
Nylok Corp., NJ
Olean Electro Plating Co., NY
Pfister Tubing Corp., NJ
Plume & Atwood Mfg. Co., Conn
Reed & Prince Mfg. Co., Mass
Reynolds Metal Co., Va
Rustproofing & Metal Finishing Corp., Mass
Sager Metal Strip Co., Ill
Sanford Process Co., Inc., Calif
Saramar Aluminum Co., Ohio
Schwartz Chemical Co., Inc., NY
Service Hard Chromium Co., NJ
Southern Aluminum Finishing Co., Inc., Ga
Spencer Nahm Co., Calif
Stevens, Frederic B, Inc., Mich
Trenton Pipe Nipple Co., NJ
Trim Alloys, Inc., Mass
Vanamatic Co., Ohio
W L S Stamping Co., Ohio
Woodstock Div., Electric Autolite Co., Ill
Youngstown Mfg. Inc., Ohio

Conversion Coatings, Chromate
(formulations)

Abalon Precision Mfg. Corp., NY
Acme Plating Co., Ohio
Alchemize Corp., Ill
Allied Chemical Corp., Solvay Process Div., NY
Allied Research Products, Inc., Md
Amchem Products, Inc., Pa
—Ad p 344
Chemical Corp., Mass
—Ad p 352
Colonial Alloys Co., Pa
Conversion Chemical Corp., Conn
—Ad p 348
Cosden Paint Co., NJ
Cowles Chemical Co., Ohio
Diamond Alkali Co., Ohio
Dollin Corp., NJ
Enthone, Inc., Conn
Heatbath Corp., Mass
Hull, R.O. & Co., Inc., Ohio
Lacquer & Chemical Corp., NY
MacDermid, Inc., Conn
Metal & Thermit Corp., NJ
Metals Engineering Corp., Tenn
Mitchell-Bradford Chemical Co., Conn
Modern Plating Corp., Ill
Neilson Chemical Co., Mich
Nylok Corp., NJ
Oakite Products, Inc., NY
Octagon Process, Inc., NY
Parker Paint Mfg. Corp., Ind
Parker Rust Proof Co., Mich
Pennsalt Chemicals Corp., Pa
Pierce & Stevens Chemical Corp., NY
Prestole Corp., Ohio
Thompson & Co., Pa
Turco Products, Inc., Calif
Vanamatic Co., Ohio
Woodstock Div., Electric Autolite Co., Ill
Zeller Corp., Ohio

Conversion Coatings, Chromate
(coaters)

Abalon Precision Mfg. Corp., NY
Accurate Anodizing Corp., Ill
Acme Plating Co., Ohio
Amchem Products, Inc., Pa
American Agile Corp., Ohio
American Emblem Co., Inc., NY
Brooks & Perkins, Inc., Mich
Cleveland Metal Products Co., Ohio
Colonial Alloys Co., Pa
Cowles Chemical Co., Ohio
Diversey Corp., Metal Industries Div., Ill
Dollin Corp., NJ
Du-Wel Metal Products, Inc., Mich
Eaton Mfg. Co., Reliance Div., Ohio
Electrofilm, Inc., Calif
Falstrom Co., NJ
Farwell Metal Fabricating, Minn
Hardy Mfg. Corp., Ind
Kelley Mfg. Co., Tex
Lacquer & Chemical Corp., NY
Metal Finishers, Inc., Md
Metal & Thermit Corp., NJ
Metals Engineering Corp., Tenn
Modern Plating Corp., Ill
National Lock Co., Ill
Norgren-Stemac, Inc., Colo
Nylok Corp., NJ
Olean Electro Plating Co., NY
Prestole Corp., Ohio
Reed & Prince Mfg. Co., Mass
Rustproofing & Metal Finishing Corp., Mass
Simoniz Products Div., Simoniz Co., Ill
Sommer Metalcraft Corp., Ind
Spencer Nahm Co., Calif
Superior Plating, Inc., Minn
United-Carr Fastener Corp., Mass
W L S Stamping Co., Ohio
Witt Cornice Co., Galvanizing Div., Ohio
Zeller Corp., Ohio

Conversion Coatings, Oxide
(formulations)

Birchwood Chemical Co., Minn
Cosden Paint Co., NJ
Cowles Chemical Co., Ohio
Dollin Corp., NJ
Du-Lite Chemical Corp., Conn
Enthone, Inc., Conn
Heatbath Corp., Mass
Houghton, E.F. & Co., Pa
Hull, R.O. & Co., Inc., Ohio
MacDermid, Inc., Conn
Mitchell-Bradford Chemical Co., Conn
Modern Plating Corp., Ill
Neilson Chemical Co., Mich
Nylok Corp., NJ
Parker Paint Mfg. Corp., Ind
Prestole Corp., Ohio
Tube Reducing Corp., NJ
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
Vanamatic Co., Ohio
Zeller Corp., Ohio

Conversion Coatings, Oxide
(coaters)

Biddle Screw Products Co., Ind
Cleveland Metal Products Co., Ohio
Diversey Corp., Metal Industries Div., Ill
Dollin Corp., NJ
Kelley Mfg. Co., Tex
Metal Finishers, Inc., Md
Metallizing Co. of Los Angeles, Inc., Calif
Modern Plating Corp., Ill
National Lock Co., Ill
Nuclear Materials & Equipment Corp., Pa
Nylok Corp., NJ
Plume & Atwood Mfg. Co., Conn
Prestole Corp., Ohio
Reed & Prince Mfg. Co., Mass
Rustproofing & Metal Finishing Corp., Mass
Spencer Nahm Co., Calif
Superior Plating, Inc., Minn
United-Carr Fastener Corp., Mass
W L S Stamping Co., Ohio
Worth Co., Wis

Conversion Coatings, Phosphate
(formulations)

Ainsworth Precision Castings Co., Div. of Harsco Corp., Mich
Amchem Products, Inc., Pa
—Ad p 344
Ashtabula Mfg. Co., Ohio
Cowles Chemical Co., Ohio
Detrex Chemical Industries, Inc., Mich
Dollin Corp., NJ
Enthone, Inc., Conn
Farrelloy Co., Pa
Fidelity Chemical Products Corp., NJ
Houghton, E.F. & Co., Pa
Hull, R.O. & Co., Inc., Ohio
Kelite Corp., NJ
MacDermid, Inc., Conn
Magnuson Products Corp., NY
Mitchell-Bradford Chemical Co., Conn
Modern Plating Corp., Ill
Neilson Chemical Co., Mich
Northwest Chemical Co., Mich
Nylok Corp., NJ
Oakite Products, Inc., NY
—Ad p 354
Octagon Process Inc., NY
Panther Chemical Corp., Tex
Parker Rust Proof Co., Mich
—Ad p 353
Pennsalt Chemicals Corp., Pa
Plume & Atwood Mfg. Co., Conn
Prestole Corp., Ohio
Rustproofing & Metal Finishing Corp., Mass
Sharon Steel Corp., Pa
Thompson & Co., Pa
Turco Products, Inc., Calif
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
Vanamatic Co., Ohio
Whitfield Chemical Co., Mich
Wyandotte Chemicals Corp., Mich
Zeller Corp., Ohio

Conversion Coatings, Phosphate
(coaters)

Almco Steel Products Corp., Ind
Amchem Products, Inc., Pa
Ashtabula Mfg. Co., Ohio
Biddle Screw Products Co., Ind
Cleveland Metal Products Co., Ohio
Diversey Corp., Metal Industries Div., Ill
Dollin Corp., NJ
Electrofilm, Inc., Calif
Ellicott-Brandt, Inc., Md
Falstrom Co., NJ
Farwell Metal Fabricating, Minn
Grand Rapids Brass Co., Mich
Hardy Mfg. Corp., Ind
Kelley Mfg. Co., Tex
Metal Finishers, Inc., Md
Modern Plating Corp., Ill
National Lock Co., Ill
National Metal Products Co., Pa
Nylok Corp., NJ
Prestole Corp., Ohio
Reed & Prince Mfg. Co., Mass
Rustproofing & Metal Finishing Corp., Mass
Simoniz Products Div., Simoniz Co., Ill
Spencer Nahm Co., Calif
Superior Plating, Inc., Minn
United Shoe Machinery Corp., Mass
United-Carr Fastener Corp., Mass
W L S Stamping Co., Ohio
Witt Cornice Co., Galvanizing Div., Ohio
Woodstock Div., Electric Autolite Co., Ill
Worth Co., Wis

Copper and Its Alloys

Acme Tube, Inc., NJ (ee)
Ajax Metal Div., H. Kramer Co., Pa (w)
Alcasco Foundry, Ill (w)
Allied Research Products, Inc., Md
(n)—Ad p 358
Alloy Metal Products, Inc., Iowa (o,w)
Alofs Mfg. Co., Mich (dd)
Alpha Wire Corp., NY (ff)
American Crucible Products Co., Ohio (o)
American Manganese Bronze Co., Pa (o,bb)
American Metal Climax, Inc., Amco Div., NY (n,o,q,w,aa)
American Metal Climax Inc., NY (n,o,q,w,aa)
American Nickel Alloy Mfg. Corp., NY (o)
American Silver Co., NY (v,dd,ee,ff)
American Smelting & Refining Co., NY (n,q,w)
American Steel and Wire Div., U. S. Steel Corp., Ohio (ff)
Ampco Metals, Inc., Wis (o,z,cc,dd,ee)
Anaconda American Brass Co., NY (o,v,z,bb,cc,dd,ee,ff)
Arcos Corp., Pa (ff)
Atlantic Powdered Metals, Inc., NY (aa)
Atlantic Steel Co., Ga (cc,dd)
Atlas Brass Foundry, Calif (o)
Auld, D.L. Co., Ohio (n,cc,dd,ff)
Avins Industrial Products Corp., NY (ee)
Avril, G.A. Co., Ohio (w)
Babson Dow Mfg. Co., Mass (o)
Baer Bros. Bronze Powder Co., Inc., Mass (aa)
Bart Mfg. Corp., NJ (aa)
Barth Smelting Corp., NJ (w)
Bay State Refining Co., Inc., Mass (w)
Belmont Smelting & Refining Works, Inc., NY (n,q,w,aa)
Beryllium Corp., Pa
(o,q,w,z,bb,cc,dd,ee,ff)—Ad p 159
Biddle Screw Products Co., Ind (o,bb,ee)
Bohn Aluminum & Brass Corp., Mich (bb,ff)
Both, O.A. Corp., Mass (aa)
Bridgeport Brass Co., Conn
(n,o,bb,cc,dd,ee,ff)—Ad p 157
Bridgeport Rolling Mills Co., Conn (dd)
Brinkerhoff Brass & Bronze Works, Inc., NY (z,bb,cc,dd,ee,ff)
Bristol Brass Corp., Conn (o,z,bb,cc,dd,ff)
Brush Beryllium Co., Ohio (o,q,w,z,dd)
Bullock, W.J., Inc., Ala (w)
Central Steel & Wire Co., Ill (o,z,bb,cc,dd,ee,ff)
Cerro Sales Corp., Sub. of Cerro Corp., NY (w,ee,ff)
Chase Brass & Copper Co., Sub of Kennecott Copper Corp., Conn (n,o,z,bb,cc,dd,ee,ff)
Chicago Extruded Metals Co., Ill (bb)
Clark Perforating Co., Mich (cc,dd)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (ff)
Continuous Cast Products Dept., American Smelting & Refining Co., NJ
(o,q,bb,ee)—Ad p 399
Copper & Brass Sales, Inc., Mich (n,o,q,v,z,bb,cc,dd,ee,ff)
Craft Metal Spinning Co., Ill (cc)
Crescent Bronze Powder Co., Ill (aa)
Designers Metal Corp., Ill (cc)
Detroit Float & Stamping Co., Mich (o,bb,dd,ee)
Dixon Sintaloy, Inc., Conn (o)
Dormont Mfg. Co., Pa (ee)
Driver, Wilbur B. Co., NJ (v,bb,dd,ff)
Driver-Harris Co., NJ (bb,dd)
Dudek & Bock Spring Mfg. Co., Ill (ff)
Eastern Rolling Mills, Inc., NY (cc,dd)
Electric Materials Co., Pa (n,o,bb)
Electronic Parts Mfg. Co., Inc., NJ (ff)
Empire Metal Co., NY (n,o)
Erskine Precision Wire Corp., Pa (ff)
Essex Industrial Products Div., Essex Wire Corp., Ind (ff)
Essex Wire Corp., Magnet Wire Div., Ind (ff)
Eynon-Dakin Co., Mich (ee)
Federated Metals Div., American Smelting and Refining Co., NY (n,o,q,w,bb,ee)
Fromson Orban Co., Inc., NY (z,cc,dd,ee)
General Cable Corp., NY (ff)
Glidden Co., Ind (aa)
Glidden Co., Chemical Divs., Metals Dept., Ind
(aa)—Ad p 397
Gold Leaf & Metallic Powders, Inc., NY (aa)
Grand Rapids Brass Co., Mich (z)
Greenback Industries, Inc., Mich (aa)
H & H Tube & Mfg. Co., Mich (b)
Hamilton Watch Co., Precision Metals Div., Pa (v,bb,cc,dd,ff)
Hardy, Charles, Inc., NY (aa)
Harris, Benjamin & Co., Ill (w)
Harshaw Chemical Co., Ohio (n)
Harvey Aluminum, Calif (o,bb)
Hayden Wire Works, Inc., Mass (ff)
Hettleman K. & Sons., Inc., Md (w)
Hodgson Foundry Co., Ill (n,o,z)
Hoffman Bronze & Aluminum Casting Co., Ohio (n)
Hommel, O. Co., Pa (aa)
Horton-Angell Co., Mass (n,o,bb,cc,dd,ee,ff)
Hoskins Mfg. Co., Mich
(bb,dd)—Ad p 148
Houston Blow Pipe & Sheet Metal Works, Tex (o,cc)
Hudson, Inc., NJ (w)
Hull, R.O. & Co., Inc., Ohio (n)
Hussey, C.G. & Co., Div. of Copper Range Co., Pa
(n,o,z,bb,cc,dd,ee,ff)—Ad p 160
Inshield Die & Stamping Co., Ohio (dd)
Inspiration Consolidated Copper Co., NY (n,o,q)
Instrument Specialties Co., Inc., NJ (dd)
International Minerals and Metals Corp, NY (w)
International Powder Metallurgy Co., Inc., Pa (z,aa,ee)
Jelliff, C.O. Mfg. Corp., Conn (ff)
Jordan-Rogers Co., Calif (ff)
K. & L. Plating Co., Pa (z)
Kassel Export Co., Inc., NJ (v,ff)
Kelsey-Hayes Co., Metals Div., NY (o,q,v,w,z,bb,cc,dd,ff)
Kenmore Machine Products, Inc., NY (ee)
Kinkead Industries, Inc., Ill (cc,dd)
Kwikset Powdered Metal Products, Calif (aa)
Lakeland Industries, Minn (z)
Laminated Shim Co., Conn (cc)
Langsenkamp, F.H. Co., Ind (o,z,bb,cc,dd,ee,ff)
Lavin, R. & Sons, Inc., Ill (n,w)
Leach & Garner Co., Industrial Div., Mass (v,bb,cc,dd,ee,ff)
Lewin-Mathes Div., Cerro Corp., Mo (q,w,bb,ee)
Lundquist Tool & Mfg. Co., Inc., Mass (cc,dd)
Mackenzie Walton Corp., RI (ee)
Magna Mfg. Co., Inc., NJ (aa)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,dd,ee,ff)
Mallory, P.R. & Co., Inc., Ind (o,bb,dd,ff)
Malone Bronze Powder Works, Inc., NY (aa)
Malone Metal Powders, Inc., NJ (aa)
McGean Chemical Co., Ohio (n,aa,dd)
McGregor-Michigan Corp., Mich (ee)
Metal & Thermit Corp., NJ (n)
Metal Goods Corp., Mo (o,z,bb,cc,dd,ee,ff)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metals Disintegrating Co. Div., American-Marietta Co., NJ (aa)
Miller Co., Conn (dd)
Modern Plating Corp., Ill (n,o,dd,ff)
Mueller Brass Co., Mich
(n,o,bb)—Ad p 404
Murray, A.B. Co., Inc., NJ (ee)
National Electric Div., H.K. Porter Co., Pa (ff)
National Lead Co., NY (ee)
Nesor Alloy Products Co., NJ (dd,ff)
New England Brass Co., Mass (cc,dd)
New England Electrical Works, Inc., NH (ff)
New England Smelting Works, Inc., Mass (w)
New Jersey Zinc Co., NY
(aa)—Ad pp 406-407
New Haven Copper Co., Conn (n,z,cc,dd)
New Jersey Metals Co., NJ (n,w)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Nippert Electric Products Co., Ohio (bb,dd,ff)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb)
Norwalk Powdered Metals, Inc., Conn (aa)
Okonite Co., Sub. of Kennecott Copper Corp., NJ (bb,ff)
Olds Alloys Co., Calif (ee)
Olin Mathieson Chemical Corp., Metals Div., NY
(cc,dd)—Ad p 149
Ormond Mfg. Co., Inc., NJ (dd,ff)
Peerless Roll Leaf Co., Div. of Howe Sound Co., NJ (v,dd)
Penn Brass & Copper Co., Pa (ee)
Phelps Dodge Copper Products Corp., NY (dd)
Phelps Dodge Refining Corp., NY (n,o)
Plasmadyne Corp., Calif (aa)
Plume & Atwood Mfg. Co., Conn (bb,cc,dd,ff)
Precision Tube Co., Inc., Pa (ee)
Rathbone Corp., Mass (o,bb)
Republic Metals Co., Inc., NY (n,w)
Revere Copper & Brass, Inc., NY
(n,o,v,z,bb,cc,dd,ee)—Ad p 153
Revere Copper & Brass, Inc., Foil Div., NY (v)
Reynolds Aluminum Supply Co., Ga (o,bb,cc,dd,ee)
Rigidized Metals Corp., NY (cc,dd)
River Smelting & Refining Co., Ohio (w)
Riverside-Alloy Metal Div., H.K. Porter Co., Inc., NJ
(bb,dd,ff)—Ad p 150
Rodney Metals, Inc., Mass (v,dd)
Roebling's, John A. Sons Div., Colorado Fuel & Iron Corp., NJ (bb,dd,ff)
Rome Mfg. Div., Revere Copper & Brass, Inc., NY (n)
Saginaw Bearing Co., Mich (o,q)
Sall, George Metals Co., Inc., Pa (w)
Sandusky Foundry & Machine Co., Ohio (ee)
Schumann, I. & Co., Ohio (w)
Scovill Mfg. Co., Mill Products Div., Conn
(bb,cc,dd,ee,ff)—Ad p 165
Sel-Rex Corp., NJ (n,aa)
Seymour Mfg. Co., Conn (bb,dd,ff)
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio (ee)
Sherwatt Equipment & Mfg. Co., Inc., NY (ff)
Sipi Metals Corp., Ill (w)
Somers Brass Co., Inc., Conn
(v,dd)—Ad p 158
Sonken-Galamba Corp., Mo (w)
Stamford Rolling Mills Co., Inc., Conn (cc)
Standard Metals Corp., Mass (ee,ff)
Stevens, Frederic B., Inc., Mich (n)
Sylvania Electric Products, Inc., Parts Div., Pa (ff)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (ff)
Terre Haute Bronze & Brass Foundry, Ind (bb,cc,dd,ee)
Texas Instruments, Inc., Metals & Controls Div., Mass (v)
Thinsheet Metals Co., Conn (cc)
Titan Metal Mfg. Co. Div., Cerro Corp., Pa (o,bb)
Triangle Conduit & Cable Co., Inc., NJ (bb,ee,ff)
Udylite Corp., Mich (n)
Ullmann, Inc., Wis (o,ee)
U.S. Bronze Powders, Inc., NJ (aa)
U.S. Metal Products Co., Pa (w)
United Wire & Supply Corp., RI (ee,ff)
Universal Castings Corp., Ill (w)
Utility Mfg. Co., Mass (o,bb)
Viking Copper Tube Co., Ohio (ee)
Volco Brass & Copper Co., NJ (cc)
Waterbury Rolling Mills, Inc., Conn (cc,dd)
Wells, A.H. & Co., Inc., Conn (ee)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd,ee)
Whitaker Metals Corp., Mo (aa)
Whitehead Metal Products Co., Inc., NY (o,z,bb,cc,dd,ee,ff)
Wisconson Centrifugal Foundry, Inc., Wis (ee)
Wolverine Tube, Div., Calumet & Hecla, Inc., Mich (ee)
Wright, Albert Screw Machine Products, Calif (bb)

Cordierite

(see Ceramics)

Cork

Armstrong Cork Co., Pa (r)
Conolite Div., Continental Can Co., Del (bb,cc,ee)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Coyne & Paddock, Inc., NY (cc)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (r,aa,cc)
Dutch Brand Div., Johns-Manville Corp., Ill (r,cc)
Enamel Products Co., Ohio (r)
General Asbestos Gasket Mfg. Corp., Mo (r)
General Gasket, Inc., Conn (r)
Hollingsworth & Vose Co., Mass (r)
National Gasket & Washer Mfg. Co., Inc., NY (r,cc)
Peerless Products Industries, Ill (r)
Sheller Mfg. Corp., Mich (r,bb,cc,ee)
Sillcocks Miller Co., NJ (r)
Spring Packing Corp., Ill (r)
Staver Co., Inc., NY (r,cc)
Superior Mfg. Co., Pa (r)
United Cork Cos., NJ (r)
Wisconsin Gasket & Mfg. Co., Wis (r)

Corrugated Metals

Aetna Steel Co., Fla (g)
Albert Pipe Supply Co., Inc., NY (g)
Aluminum Co. of America, Pa (a)
Armco Steel Corp., Ohio (g)
Atlantic Steel Co., Ga (g)
Bethlehem Steel Co., Pa (g)
Cartwright, R. Tube Products Co., Mich (a)
Clendenin Bros., Inc., Md (a)
Cobra Metal Hose Div., DK Mfg. Co., Ill (b,f,h)
Colonial Alloys Co., Pa (a)
Conner Mfg. Co., Ky (c)
Division Lead Co., Ill (d)
Dormont Mfg. Co., Pa
Edgcomb Steel & Aluminum Corp., NJ (a,g)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (g)
Esco Corp., Ore (g)
Gallfoy Cornice Works, Calif (a,c)
Illinois Zinc Co., Div. of Hydrometals, Inc., Ill (j)
Inland Steel Co., Ill (g)
Johnson Metal Hose, Inc., Conn (b,f,g)
Jones & Laughlin Steel Corp., Pa (g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kelley Mfg. Co., Tex (a,g)
Levinson Steel Co., Pa (a,g)
New York Iron Roofing & Corrugating Co., Inc., NJ (a,g)
Olin Mathieson Chemical Corp., Metals Div., NY (a)
Powell Pressed Steel Co., Ohio (a,g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (a,b)
Reynolds Aluminum Supply Co., Ga (a,g)
Reynolds Metals Co., Va (a)
Rockwell Engineering Co., Ill (a,b,c,g)
Ryerson, Joseph T. & Son, Inc., Ill (g)
Staver Co., Inc., NY (a,b,c,d,e,f,g,h,j)
Sun Steel Co., Ill (a,g,h)
U.S. Steel Corp., Pa (g)

Cupro-Nickel

(see Copper)

Diallyl Phthalate

(DAP)
Alcylite Plastics & Chemical Corp., Calif (x,y)
Chemicals & Plastics Div., Food Machinery & Chemical Corp., NY (p,x,y)
Cordo Chemical Corp., Conn (x,y)
Durez Plastics Div., Hooker Chemical Corp., NY
(y)—Ad pp 262-263
Dyna-Therm Chemical Corp., Calif (p)
F M C Organic Chemicals Div., Food Machinery & Chemical Corp., NY (p)
Fiber Glass Industries, Inc., NY (x,y,cc)
Formica Corp., Sub. of American Cyanamid Corp., Ohio (bb,cc,dd)
Hays Mfg. Co., Pa (y)
Maloney, F.H. Co., Tex (y)
Mesa Plastics Co., Calif
(p,y,bb,cc)—Ad p 268

Rogers Corp., Conn
(y)—Ad pp 270-271
Specialty Resins Co., Calif (p,x)
Synthane Corp., Pa (bb,cc,dd,ee)
U.S. Polymeric Chemicals, Inc., Conn (x,y)

Diamond

(see Carbon, Graphite)

Die Castings

(see Castings)

Diffusion Coatings

(calorized, chromized, sherardized)
Alloy Surfaces Co., Inc., Del
Calorizing Co., Pa
Chromalloy Corp., NY
Chromizing Corp., Calif
Colonial Alloys Co., Pa
General Extrusions, Inc., Ohio
Kelley Mfg. Co., Tex
Metal Finishers, Inc., Md
Modern Plating Corp., Ill
Nylok Corp., NJ
Rustproofing & Metal Finishing Corp., Mass
Sheldon, M. L. & Co., Inc., NY
Vanamatic Co., Ohio

Dip Coatings

(see Immersion Coatings; Galvanizers)

Dispersion Coatings

(see Organic Coatings)

Drawn, Pressed Parts

(not incl. stampings)
Abalon Precision Mfg. Corp., NY (a,b,c,g)
Acme Metal Spinning, Inc., Minn (a,b,c,d,e,f,g,h,j)
Acme Stamping & Wire Forming Co., Pa (a,b,g)
Acorn Sheet Metal Mfg. Co., Inc., Ill (a,g)
Alco Products, Inc., NY (g)
AllianceWall Div., AllianceWare, Inc., Ohio (g)
Alloy Products Corp., Wis
(a,f,g,h)—Ad p 434
Aluminum Co. of America, Pa (a)
Aluminum Goods Mfg., Wis (a,g)
Aluminum Specialty Co., Wis (a,g)
American Aluminum Co., NJ (a,b)
American Car & Foundry Div., ACF Industries, Inc., NY (a,e,g)
American Forge & Mfg. Co., Pa (g)
American Machine & Foundry Co., Cleveland Welding Div., Ohio (f,g,h)
American Silver Co., Inc., NY (a,b,e,f,g)
Anaconda American Brass Co., NY (a,b,g)
Anchor Metal Spinning Co., Ohio (a,b,c,d,f,g)
Anthes Div., Gleason Corp., Iowa (a,g)
Armco Steel Corp., Sheffield Div., Mo (g)
Arrow Metal Products Corp., NJ (a)
Arvin Industries, Inc., Ind (a,g)
Associated Spring Corp., Wallace Barnes Steel Div., Conn (g)
Atlas Metal Parts Co., Wis (a,b,c,g)
Auld, D.L. Co., Ohio (c)
Belmont Smelting & Refining Works, NY (a,b,g)
Bethlehem Steel Co., Pa (g)
Bishop, J. & Co. Platinum Works, Pa
Boots Aircraft Nut Corp., Conn (g)
Brooks & Perkins, Inc., Mich
(a,e,g,h)—Ad p 420
Brown Lipe Chapin Div., General Motors Corp., NY (g)
Butler Mfg. Co., Mo (a,g)
Cly-Del Mfg. Co., Conn (a,b,f,g,j)
Colonial Alloys Co., Pa (a)
Columbus Bolt & Forging Co., Ohio (a,b,g)
Commercial Shearing & Stamping Co., Ohio (a,f,g)
Consolidated Fruit Jar Co., NJ (a,b,c,d,g,j)
Cooley, W.J. & Co., Tenn (a,b,c,g)
Croname Inc., Ill (a,b,g)
Crosby Co., NY (a,b,g)
Crown Metal Co., Wis (d)
Custom Tool & Mfg. Co., Minn
Cuyahoga Stamping Co., Ohio (a,b,g)
Cyril Bath Co., Ohio (a,e,f,g,h)
Dahlin, C. A. Co., Ill (a,b,d,e,f,g,j)
Dana Corp., Auburn Div., Ind (g)
Dayton Rogers Mfg. Co., Minn (a,b,c,g,j)
Detroit Stamping Co., Mich (a,b,g)
Dirilyte Co. of America, Inc., Ind (a,b)
Division Lead Co., Ill (d)
Dow Chemical Co., Mich (a,e)
Earley, Sam C. Corp., Ohio
Eastern Tool & Mfg. Co., NJ (a,b,c,d,g,h)
Eastern Tool & Stamping Co., Inc., Mass (a,b,c)
Eaton Mfg. Co., Reliance Div., Ohio (g)
Edgcomb Steel & Aluminum Corp., NJ (g)
Electric Autolite Co., Ohio (c)
Electric Materials Co., Pa (b)
Electro-Chemical Engineering Co., NY (a,b,g)
Ellicott-Brandt, Inc., Md (a,b,e,g)
Esco Corp., Ore (g)
Evans, George Corp., Ill (a)
Falstrom Co., NJ (a,b,e,f,h)
Farwell Metal Fabricating, Minn (a,b,e,f,g)
Firestone Steel Products Co. Div., Firestone Tire & Rubber Corp., Ohio (a,g)
Fletcher Enamel Co., W. Va (a,b,c,d,e,f,g)
Forg, Peter Mfg. Co., Mass (a,b,c,h)
Frasse, Peter A. & Co., Inc., NY (a,g)
Garco Mfg. Co., Inc., Ill (a,b,c,e,f,g,h,j)
General Alloys Co., Mass (a,b,f)
General Findings & Supply Co., Industrial Div., Mass (b,f,g)
Geuder, Paeschke & Frey Co., Wis (a,c,f,g)
Grammes, L.F. & Sons, Inc., Pa (a,b,c,g)
H & H Tube & Mfg. Co., Mich (b)
Hunter Corp., Pa (b,c,f,g)
Hunter Spring Co. Div., American Machine & Metals, Inc., Pa (a,b,f,g)
Hydroforming Co. of America, Ill (a,b,f,g,h)
Ideal Can Co., Mass (a,b,g)
Illinois Zinc Co., Div. of Hydrometals, Inc., Ill (j)
Ingersoll Products Div., Borg-Warner Corp., Ill (g)
Inland Steel Co., Ill (g)
International Silver Co., Eyelet Specialty Div., Conn (a,b,g)
Irwin-Sensenich Corp., Pa (a,g)
Jones & Laughlin Steel Corp., Pa (g)
Kees, F.D. Mfg. Co., Neb (a,g)
Kelley Mfg. Co., Tex (a,g)
Kelsey-Hayes Co., Mich (g)
Kickhaefer Mfg. Co., Wis (a,b,g)
Kling Metal Spinning & Stamping Co., NY (a,b,c,d,e,f,g,j)
Koehler Mfg. Co., Mass (a,b,c,g)
Lakewood Metal Products, Inc., Conn
Lansing Stamping Co., Mich (g)
Latrobe Steel Co., Pa (g)
Leake Engineering Co., Mich (a,b,c,d,e,f,g,h,j)
Leake Stamping Div., Monarch Products Co., Mich (a,b,g)
Lenape Hydraulic Pressing & Forging Co., Pa (a,b,g)
Lukens Steel Co., Pa (a,b,e,f,g,h)
Lundquist Tool & Mfg. Co., Inc., Mass (a,g)
Magline, Inc., Mich (a,e)
Magnesium Products of Milwaukee, Inc., Wis (a,e)
Mahon, R.C. Co., Mich (a,g)
Manganese Steel Forge Co., Pa (g)
Manufacturers Service, Inc., Ohio (a,b,g)
Matthiessen & Hegeler Zinc Co., Ill (j)
Metals Engineering Corp., Tenn (a,b,d,e,f,g,j)
Midwest Stamping & Mfg. Co., Ohio (a,b,f,g)
Milwaukee Stamping Co., Wis (a,b,g)
Mirro Aluminum Co., Wis (a)
Morse, Fred W. Co., RI (a,b,c,g,j)
Morton Mfg. Co., Ill (a,g)
National Metal Products Co., Pa (a,b,d,g,j)
National Moldite Co., NJ (c)
Nichols, L.O. & Son Mfg. Co., Mo (a,b,c,g)
Nichols Wire & Aluminum Co., Iowa (a)
Nippert Electric Products Co., Ohio (b)
Olean Electro Plating Co., NY (a,b,g)
Olderman Mfg. Corp., Conn (b)
Olin Mathieson Chemical Corp., Metals Div., NY (b)
Parish Pressed Steel Div., Dana Corp., Pa (a,g)
Peterson Products Corp., Ill (a,b,f,g)
Phoenix Products Co., Wis (a,b,c,e,f,g)
Phoenix Steel Corp., NY (a,b,g)
Pioneer Stamped Products Co., NY (a,b,e,f,g)
Pittsburgh Steel Co., Pa (g,j)
Plume & Atwood Mfg. Co., Conn (a,b,c,f,g,l)
Polar Ware Co., Wis (a,b,f,g)
Powell Pressed Steel Co., Ohio (a,g)
Precision Extrusions, Inc., Ill (a)
Pressed Steel Co., Pa (a,b,f,g)
Pressed Steel Tank Co., Wis (a,b,c,e,f,g,h)
Queen Products Co., Inc., Ky (a,g)
Regal Ware, Inc., Wis (a,b,g)
Reichert Float & Mfg. Co., Ohio
(a,b,c,d,f,j)—Ad p 418
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (a,b)
Reynolds Metals Co., Va (a)
Rockwell Engineering Co., Ill (a,b,c,g)
Rockwell-Standard Corp., Stamping Div., NY (a,b,d,f,g)
Rohr Aircraft Corp., Calif (a,e,g,h)
Rolock, Inc., Conn (f)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
Scaife Co., Pa (a,c,f,g)
Schrader, J. Co., Ohio (a,b,c,d,e,f,g,j)
Scovill Mfg. Co., Mill Products Div., Conn (a,b,c,f,g)
Shank Metal Products Co., NY
Simonsen Metal Products Co., Ill (a,g)
Smoot-Holman Co., Calif (g)
Southern Metal Products Co., La (a,g)
Southwestern Porcelain Steel Corp., Okla (g)
Spincraft, Inc., Wis (a,b,c,d,e,f,g,h,j)
Star Stamping Co., Mich (a,b,g)
Staver Co., Inc., NY (a,b,c,d,e,f,g,h,j)
Stimpson, Edwin B. Co., Inc., NY (a,b,f,g,j)
Stirrup Metal Products Corp., NJ (a,b,c,g)
Superior Mfg. Co., Pa (g)
Superior Spinning & Stamping Co., Ohio (a,b,f,g)
Sylvania Electric Products, Inc., Parts Div., Pa (a,b,c,f,g)
Teiner, Roland Co., Inc., Mass (a,b,f,g)
Texas Instruments, Inc., Metals & Controls Div., Mass (a,b,c,e,f,g,h,j)
Textile Shield Co., Inc., Mass (a,b,g)
Thompson-Bremer & Co., Ill (a,b,c,f,g,h)
Titan Metal Mfg. Co. Div., Cerro Corp., Pa (b)
Torrington Co., Conn (a,b,f,g)
Trenton Pipe Nipple Co., NJ (b,g)
Triangle Stamping Co., Ohio (a,b,c,d,f,g,j)
United-Carr Fastener Corp., Mass (a,b,g)
Van Huffel Tube Corp., Ohio (a,b,g)
Volkert Stampings, Inc., NY (b,f,g)
Vollrath Co., Wis (g)
Vulcan-Kidd Steel Div., H. K. Porter Co. Inc., Pa (g)
Warren Plastics & Engineering, Inc., Mich (a,b,c,d,e,f,g,h,j)
Waterbury Cos., Inc., Conn (a,b,g)
Waterbury Pressed Metal Co., Conn (a,b,f,g)

Waterman Industries, Inc., Calif (a,b,g)
Wayne Foundry & Stamping Co., Mich (a,b,e,g,h)
Wesbar Stamping Corp., Wis (a,b,c,g)
Williams, H. E. Products Co., Mo (a,b,c,g,j)
Wilson-Hurd Mfg. Co., Inc., Wis (a)
Worcester Pressed Steel Co., Mass (a,b,c,e,f,g,h,j)
Worcester Stamped Metal Co., Mass (a,b,f,g,h,j)
Wuest Bros., Inc., Ky (a,b,c,f,g)
Wycoff Steel Co., Pa (g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)
Youngstown Mfg., Inc., Ohio (a,g)

Drop Forgings
(see Forgings)

Ductile Iron
(see Iron)

Electrodes, Welding
(see Filler Metals)

Electroless Coatings
(see Immersion Coatings)

Electroplated Coatings
(Electroplaters; see also Preplated Metals)

Abalon Precision Mfg. Corp., NY
Accurate Anodizing Corp., Ill
Acme Plating Co., Ohio
Ainsworth Precision Castings Co., Div. of Harsco Corp., Mich
Allied Chemical Corp., Plastics Div., NY
Allied Research Products, Inc, Md
Aluminum Billets, Inc., Ohio
American Emblem Co., Inc., NY
American Nickeloid Co., Ill
American Platinum & Silver Div., Engelhard Industries, Inc., NY
American Sanitary Mfg. Co., Ill
American Smelting & Refining Co., NY
Apollo Metals, Inc., Ill
Atlantic Brass Works, Inc., Ill
Atlantic Steel Co., Ga
Auld, D.L. Co., Ohio
Barrett Chemical Products Co., Inc., Conn
Bart Mfg. Corp., NJ
Bethlehem Steel Co., Pa
Bishop, J. & Co. Platinum Works, Pa
Boyles Galvanizing & Plating Co., Tex
Brown Lipe Chapin Div., General Motors Corp., NY
Brewer-Titchener Corp., NY
Brooks & Perkins, Inc., Mich
Chicago Hardware Foundry Co., Ill
Chromium Corp. of America, NY
Cohan Epner Co., Inc., NY
Colonial Alloys Co., Pa
Columbus Dental Mfg. Co., Ohio
Commercial Screw Products Co., Ohio
Conforming Matrix Corp., Ohio
Continental Die Casting Corp., Mich
Cowles Chemical Co., Ohio
Croname, Inc., Ill
Designers Metal Corp., Ill
Diamond Alkali Co., Ohio
Diversey Corp., Metal Industries Div., Ill
Doehler-Jarvis Div., National Lead Co., Ohio
Dollin Corp., NJ
Du-Wel Metal Products, Inc., Mich
Eaton Mfg. Co., Reliance Div., Ohio
Edna Lite Optical Co., Inc., NY
Electric Autolite Co., Ohio
Electric Materials Co., Pa
Elmet Div., North American Phillips Co., Inc., Me
Fox Co., Ohio
General Chain & Mfg. Corp., Ohio
General Findings & Supply Co., Industrial Div., Mass
Grand Rapids Brass Co., Mich
Hamilton Die Cast, Inc., Ohio
Hardy Mfg. Corp., Ind
Harshaw Chemical Co., Ohio
Hilfinger Corp., Ohio
Hull, R.O. & Co., Inc., Ohio
Indium Corp. of America, NY
Industrial Chromium Corp., Mass
Jervis Corp., Mich
K. & L. Plating Co., Pa
Kees, F.D. Mfg. Co., Neb
La France Precision Casting Co., Pa
Lakeland Industries, Minn
Litho-Strip Corp., M.M. Young Div., Ill
Lundquist Tool & Mfg Co., Inc., Mass
MacDermid, Inc., Conn
Marlane Development Co., Inc., NY
Master Chrome Service, Inc., Ohio
McGean Chemical Co., Ohio
Mechanical Plating Co., Ill
Medico Industries, Inc., Pa
Merrimac Brass, Mass
Metal Finishers, Inc., Md
Metal & Thermit Corp., NJ
Metals Engineering Corp., Tenn
Metaplast Process, Inc., NY
Michigan Chrome & Chemical Co., Mich
Modern Plating Corp., Ill
National Malleable & Steel Castings Co., Ohio
National-Standard Co., Mich
New Jersey Metals Co., NJ
New Jersey Zinc Co., NY
Norgren-Stemac, Inc., Colo
Nylok Corp., NJ
Olean Electro Plating Co., NY
Ormond Mfg. Co., Inc., NJ
Penn Metal Co., Inc., W. Va
Pittsburgh Steel Co., Pa
Plume & Atwood Mfg. Co., Conn
Reed & Prince Mfg. Co., Mass
Republic Die Casting Div., Landers Frary & Clark, Ark
Republic Steel Corp., Ohio
Rustproofing & Metal Finishing Corp., Mass
Ryerson, Joseph T. & Son, Inc., Ill
St. Eloi Corp., Ohio
St. Louis Diecasting Corp., Mo
Seal-Peel, Inc., Mich
Service Hard Chromium Co., NJ
Sifco Metachemical, Inc., Ohio
Sommer Metalcraft Corp., Ind
Southern Metal Products Co., La
Spencer Nahm Co., Calif
Steel Protection & Chemical Co., Ind
Stevens, Frederic B., Inc., Mich
Stirrup Metal Products Corp., NJ
Superior Plating, Inc., Minn
Sylvania Electric Products, Inc., Parts Div., Pa
Texas Instruments, Inc., Metals & Controls Div., Mass
Tiarco Corp., NJ
Trenton Pipe Nipple Co., NJ
Tubular Rivet & Stud Co., Mass
United Refining & Smelting Co., Ill
United-Carr Fastener Corp., Mass
Vanamatic Co., Ohio
Van der Horst Corp., NY
Van Valkenburg, L.D. Co., Mass
WLS Stamping Co., Ohio
Waldman, Joseph & Sons, Epoxy Products Div., NJ
Wayne Foundry & Stamping Co., Mich
Wesbar Stamping Corp., Wis
Western Coating Co., Mich
Williams Gold Refining Co., Inc., NY
Woodstock Div., Electric Auto-Lite Co., Ill
Worth Co., Wis
Wright Metalcoaters, NJ
Wyandote Chemicals Corp., Mich
Zeller Corp., Ohio

Embossed Metals
(incl. rigidized)

Aluminum Co. of America, Pa (a)
American Nickeloid Co., Ind. (a,b,g,j)
Ardmore Products, Inc., NJ (a,b,c,d,e,f,g,h,j)
Atlantic Steel Co., Ga (a,b,g)
Auld, D.L. Co., Ohio (a,b)
Avery Label Co., Calif (a)
Colonial Alloys Co., Pa (a)
Cooley, W.J. & Co., Tenn (a,b,c,g)
Copper & Brass Sales, Inc., Mich (a)
Croname Inc., Ill (a,b,f,g,j)
Esco Corp., Ore (a,b,c,g)
Fairmont Aluminum Co., Va (a)
Falstrom Co., NJ (a,b,e,f,g,h)
Grammes, L.F. & Sons, Inc., Pa (a,b,g)
Grigoleit Co., Ill (a,g)
Hawkridge Bros. Co., Mass (a)
Haydon Corp., NY (a,g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Langsenkamp, F.H. Co., Ind (a)
Mahon, R.C. Co., Mich (a)
McKinney Mfg. Co., Pa (a,b,e,f,g)
Metal Goods Corp., Mo (a)
Meier Brass & Aluminum Co., Mich (a)
Morse, Fred W. Co., RI (a,b,c,g)
Olin Mathieson Chemical Corp., Metals Div., NY (a)
Pittsburgh Steel Co., Pa (g)
Premier Metal Works, Inc., Ill (a,b,f,g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (a)
Reynolds Aluminum Supply Co., Ga (a)
Reynolds Metal Co., Ky (a)
Rigidized Metals Corp., NY (a,b,f,g,h)
Rockwell Engineering Co., Ill (a,b,c,g)
Ryerson, Joseph T. & Son, Inc., Ill (a)
Sager Metal Strip Co., Ill (a)
Sharon Steel Corp., Pa (g)
Simoniz Products Div., Simoniz Co., Ill (a,g)
Southern Aluminum Finishing Co., Inc., Ga (a)
Southwestern Porcelain Steel Corp., Okla (g)
Sun Steel Co., Ill (a,g,h)
Thomas Strip Div., Pittsburgh Steel Co., Pa (g)
Wesbar Stamping Corp., Wis (a,b,c,g)
Whitehead Metal Products Co., Inc., NY (a,b,f,g)
Wilson-Hurd Mfg. Co., Inc., Wis (a)

Emulsion Coatings
(see Organic Coatings)

Enamels
(see Organic Coatings)

Epoxies

Adhesive Products Corp., NY (x)
Alcylite Plastics & Chemical Corp., Calif (p)
Amercoat Corp., Calif (ee)
American Metaseal Corp., NJ (x,ee)
American-Marietta Co., Adhesive, Resin & Chemical Div., Wash (p,y)
Angier Adhesives Div., Interchemical Corp., Mass (x)
Aries Laboratories, Inc., Conn (p,x,y)
Armstrong Products Co., Ind (x)
Atlas Mineral Products Co., Pa (x)
Biggs, Carl H. Co., Inc., Calif (t,x,y)
Bisonite Co., Inc., NY (x)
Booty Resineers Div., American-Marietta Co., Ohio (y)
Borden Chemical Div., Borden Co., NY (p)
Cadillac Plastic & Chemical Co., Mich (x)
Chemical Coatings & Engineering Co., Inc., Pa (p,x)
Chemical Development Corp., Mass (p,x)
Chemicals and Plastics Div., Food Machinery & Chemical Corp., NY
(p,y)—Ad p 214
Ciba Products Corp., NJ
(p,x)—Ad pp 220-221
Cleveland Container Co., Ohio (ee)
Clinton Co., Ill (x,y)
Coast Pro-Seal & Mfg. Co., Calif (x)
Colonial Kolonite Co., Ill (bb,cc)
Comco Plastics, Inc., NY (bb,cc,dd,ee)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Co-Polymer Chemicals Inc., Mich (x)
Cordo Chemical Corp., Conn (x,y)
Carbell, Inc., NY (bb,cc,ee)
Dayton Rubber Co., Ohio (x,y)
Dennis Chemical Co., Mo (y)
Devcon Corp., Mass (x,y)
Douglas & Sturgess, Calif (x)
Dow Chemical Co., Plastics Div., Mich
(p,x)—Ad pp 249-256
Dyna-Therm Chemical Corp., Calif (p)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Electrofilm, Inc., Calif (t)
Electronic Production & Development, Inc., Chemical Div., Calif (x,y)
Emerson & Cuming, Inc., Mass (p,u,x,bb)
Fiber Glass Industries, Inc., NY (x,y,cc)
Fibercast Div., Youngstown Sheet & Tube Co., Okla (ee)
Formica Corp., Sub. of American Cyanamid Co., Ohio (cc,ee)
Foss Mfg. Co., Id (u,x)
Fry Plastics International, Calif (p,z)
Fuller, H.B. Co., Minn (x)
Furane Plastics, Inc., Calif (x,y)
Galigher Co., Utah (p,s,x)
General Electric Co., Laminated Products Dept., Ohio (bb,cc,ee)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

General Plastics Mfg. Co., Wash (x)
Glass Reinforced Plastics Corp., Ohio (bb,ee)
Glo-Brite Products, Inc., Ill (u)
Hardman, H.V. Co., Inc, NJ (x)
Hauger-Beegle Asso., Inc., Ill (t,x)
Hexcel Products, Inc., Calif
Hiller Aircraft Corp, Adhesive Engineering Div., Calif (t,u,x)
Hysol Corp., NY
(p,x,y,bb,cc,dd,ee)—Ad p 247
Insulation Mfrs. Corp., Ill (x)
Jones-Dabney Co., Div. of Devoe & Raynolds Co., Inc., Ky (p,x)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Kish Industries, Inc., Mich (x)
Knight, Maurice A. Co., Ohio (ee)
Kurz, Kasch, Inc., Ohio (y)
Maloney, F.H. Co., Tex (x,y)
Marblette Corp., NY (x,y,bb)
Mesa Plastics Co., Calif
(p,y,bb,cc)—Ad p 268
Mica Corp., Calif (cc)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (cc)
Micarta Div., Westinghouse Electric Corp., SC (x,y)
Miller-Stephenson Chemical Co., Inc., Conn (p,y,bb)
Minnesota Mining & Mfg. Co., Missile Industry Liaison, Minn
(p,y)—Ad p 367
Narmco Industries, Inc., Narmco Materials Div., Calif (u,x,y,dd)
National Vulcanized Fibre Co., Del (cc)
New England Laminates Co., Inc., Conn (cc)
Norrich Plastics Corp., NY (bb,cc,dd,ee)
Northern Plastics Corp., Wis (cc,dd)
Ohio Adhesives Corp., Ohio (x)
Panelyte Div., St. Regis Paper Co., NJ (x,bb,cc,dd,ee)
Permacel, NJ (p,x,y)
Permali, Inc., Pa (ee)
Philrus Products Co., NJ (bb,cc,dd,ee)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Poly Resins, Calif (p,x)
Polygon Plastic Co., Ind (ee)
Porter, William Co., Calif (cc,ee)
Products Research Co., Calif (y)
Pyrosil, Inc., Ohio (x,cc)
Radiation Applications, Inc., NY (x)
Raybestos-Manhattan, Inc., Plastic Products Div., Pa (x,cc)
Raybestos-Manhattan, Inc., Raybestos Div., Conn (p,x)
Reichhold Chemicals, Inc., NY (p,x)
Ren Plastics, Inc., Mich (p,x,y,ee)
Reynolds Chemical Products Co., Mich (p,x)
Rezolin, Inc., Calif (p,x)
Richardson Co., NY (bb,cc,ee)
Rogers Corp., Conn (y)
Roller Reinforced Plastics, Ohio
Royston Laboratories, Inc., Pa (x)
Schramm Fiberglass Products, Inc., Ill (u,x,y)
Schwartz Chemical Co., Inc., NY (x)
Shell Chemical Co., NY (p)
Spaulding Fibre Co., Inc., NY (bb,cc,dd,ee)
Specialty Resins Co., Calif (x,y)
Strick Plastics Co., Pa (u,cc)
Sun Chemical Corp., Electro Technical Div., NJ (x)
Superior Carbon Products, Inc., Ohio
Swedlow, Inc., Calif (cc)
Synthane Corp., Pa (bb,cc,dd,ee)
Tanner Engineering Co., Calif (ee)
Taylor Fibre Co., Pa (bb,cc,dd,ee)
Thiokol Chemical Corp., NJ (p)
Union Carbide Plastics Co., Div. of Union Carbide Corp., NY
(p,x)—Ad p 261
U.S. Gypsum Co., Ill (x)
U.S. Polymeric Chemicals, Inc., Conn (s,y)
Waldman, Joseph & Sons, Epoxy Products Div., NJ
(x,y,cc)—Ad p 460
Western Backing Corp., Calif (y)
Williamson Adhesives, Inc., Ill (x)

Ethyl Cellulose

Acadia Synthetic Products Div., Western Felt Works, Ill (ee)
Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,dd,ee)
American Molding Powder & Chemical Co., NY (y)
American Products Mfg. Co., Inc., La (t)
Anchor Plastics Co., Inc., NY (bb,dd,ee)
Auburn Plastics, Inc., NY (bb,dd,ee)
Bamberger, Claude P., Inc., NJ (y)
Bischoff Chemical Corp., NY (u)
Campco Div., Chicago Molded Products Corp., Ill (t,cc)
Carroll, J.B. Co., Ill (cc)
Coating Products, Inc., NJ (t,cc)
Continental-Diamond Fibre Corp., Del (ee)
Crane Plastics, Inc., Ohio (bb,dd,ee)
CrystalX Corp., Pa (bb,cc,dd,ee)
Davis, Joseph Plastics Co., NJ (t,y,bb,cc,dd,ee)
Denver Plastics, Inc., Colo (u)
Dow Chemical Co., Plastics Div., Mich
(p,x,y,cc)—Ad pp 249-256
Dyna-Therm Chemical Corp., Calif (p)
General Plastics Mfg. Co., Wash (bb,cc,dd,ee)
Gering Plastics, Div. of Studebaker-Packard Corp., NJ (y,bb,dd,ee)
Glass Laboratories, NY (bb,dd,ee)
H & R Plastics Industries, Inc., Pa (bb,cc,dd,ee)
Hall Mfg. Corp., NJ (dd,ee)
Hercules Powder Co., Inc., Del (p)
Heyden Newport Chemical Corp., American Plastics Corp. Div., NY (bb,cc,dd,ee)
Hydrawlik Co., NJ (bb,dd)
Industrial Plastics Corp., Ind (bb,dd)
K S H Plastics, Inc., Mo (bb,cc,dd)
Lus-Trus Corp., Mich (cc)
Muehlstein, H. & Co., Inc., NY (y)
Omni Products Corp., NY (y,bb,cc)
Perfex Plastics, Inc., Ill (bb,dd,ee)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Pyramid Plastics, Inc., Ill (bb,dd,ee)
Schwab Plastic Corp., Mich (bb,cc,dd,ee)
Simon Products Co., Ill (t)
Southern Plastics Co., SC (bb,cc,dd,ee)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., Ill (bb,ee)
Western Felt Works, Ill (cc)
World Plastics, NY (bb,cc,dd,ee)

Expanded Metals

Aluminum Co. of America, Pa (a)
Aluminum Specialty Co., Wis (a)
American Metal Products, Inc., Ohio (g)
Atlantic Steel Co., Ga (g)
Avon Tube Div., Higbie Mfg. Co., Mich (g)
Biersach & Niedermeyer Co., Wis (a,b,c,f,g)
Bishop, J. & Co. Platinum Works, Pa
Castle, A.M. & Co., Ill (a,g)
Central Steel & Wire Co., Ill (a,g)
Colonial Alloys Co., Pa (a)
Designers Metal Corp., Ill (a,b,d,e,f,g,j)
Edgcomb Steel & Aluminum Corp., NJ (a,g)
Ellwood City Iron & Wire Co., Pa (c)
Exmet Corp., NY (a,b,c,d,e,f,g,h,j)
Evans, George Corp., Ill (a)
Flexonics Corp., Ill (g)
Hawkridge Bros. Co., Mass (a)
Haydon Corp., NY (a,g)
Hazledine, E.T. Co., Ind (g)
Houston Blow Pipe & Sheet Metal Works, Tex (g)
Ideal Can Co., Mass (g)
Kees, F.D. Mfg. Co., Neb (g)
Levinson Steel Co., Pa (a,g)
Metal Goods Corp., Mo (g)
Mid-West Wire Products Co., Inc., Mich (g)
Penn Metal Co., Inc., Mass (a,b,c,d,f,g,h,j)
Republic Steel Corp., Ohio (g)
Reynolds Aluminum Supply Co., Ga (a,g)
Rockwell Engineering Co., Ill (a,b,c,g)
Rolled Alloys, Inc., Mich (f)
Rolock Inc., Conn (f)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
Simoniz Products Div., Simoniz Co., Ill (a,g)
Southern Electric, Inc., Designers Metal Div., Ill (a,b,c,f,g,j)
Standard Metals Corp., Mass (f)
Trenton Pipe Nipple Co., NJ (b,g)
Trojan Steel Co., W. Va (g)
U.S. Gypsum Co., Ill (a,g)
Vulcan Rail & Construction Co., NY (g)
Ward, H.H. Co., Pa (g)
Wheeling Corrugating Co., W.Va (g)
Wheeling Steel Corp., W.Va (g)
Whitehead Metal Products Co., Inc., NY (a,f)
Whyte, Oliver Co., Inc., NY (a,g)
Wire & Iron Products, Inc., Mich (f,g)

Extrusions

(see below; also Impact Extrusions; Tubing)

Extrusions, Metallic

(excl. Tubing, Pipe)

Accurate Metal Weather Strip Co., Inc., NY (a,b)
Adams Engineering Co., Inc., Fla (a)
Aerolite Extrusion Co., Ohio (a)
Allegheny Ludlum Steel Corp., Pa (g)
Aluminum Co. of America, Pa (a,e)
Aluminum Billets, Inc., Ohio (a)
Aluminum Extrusions, Inc., Mich (a)
American Machine & Foundry Co., Cleveland Welding Div., Ohio (g,h)
American Reed Co., Inc., Mass (e)
Ampco Metal, Inc., Wis (b)
Anaconda American Brass Co., NY (b)
Armco Steel Corp., Sheffield Div., Mo (g)
Arvin Industries, Inc., Ind (a)
Atlantic Steel Co., Ga (a)
Auld, D.L. Co., Ohio (a)
B & T Metals Co., Ohio (a)
Babcock & Wilcox Co., Tubular Products Div., Pa
(g)—Ad p 423
Badger Aluminum Extrusions, NY (a)
Beck, I. & Sons, Inc., NY (a,b)
Belmont Aluminum Extrusion Co., Pa (a)
Benada Aluminum Products Co., Ohio (a)
Beryllium Corp., Pa (b)
Bohn Aluminum & Brass Corp., Mich (a,b)
Bonnell, William L. Co., Inc., Ga (a)
Bridgeport Brass Co., Conn
(b)
Brinkerhoff Brass & Bronze Works, Inc., NY (a,b)
Bristol Brass Corp., Conn (b)
Bunker Hill Co., Calif (d)
Burgess-Norton Mfg. Co., Ill (c)
Cameron Iron Works, Inc., Special Products Div., Tex (c,f,g,h)
Capitol Products Corp., Pa (a)
Castle, A.M. & Co., Ill (a)
Central Steel & Wire Co., Ill (a)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (a,b,f,g)
Clendenin Bros., Inc., Md (a,b)
Colonial Alloys Co., Pa (a)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (g)
Columbus Bolt & Forging Co., Ohio (a,b,g)
Consolidated Fruit Jar Co., NJ (d)
Copper & Brass Sales, Inc., Mich (a,b,e)
Corson Industries, Pa (a)
Craft Mfg. Co., Ill (a,b,c,e,f,g,h,j)
Croname, Inc., Ill (a)
Crown Metal Co., Wis (d)
Curtiss-Wright Corp., Metals Processing Div., NY (f,g,h)
Custom Tool & Mfg. Co., Minn
Cyril Bath Co., Ohio (a,h)
Detroit Gasket & Mfg. Co., Extruded Metals Div., Mich (a)
Division Lead Co., Ill (d)
Dixie Aluminum Corp., Ga (a)
Dixie Bronze Co., Ala (b)
Doehler-Jarvis Div., National Lead Co., Ohio (a)
Dow Chemical Co., Mich (a,e)
Dresser Mfg. Div., Dresser Industries, Inc., Pa (f,g)
Electro-Chemical Engrg. Co., NY (a)
Empire Metal Co., NY (d)
Eureka Electric Products, Inc., Pa (b)
Fletcher Enamel Co., W. Va (a,b,c,d,e,f)
Flynn, Michael Mfg. Co., Pa (a)
Frasse, Peter A. & Co., Inc., NY (g)
Fromson Orban Co., Inc., NY (a)
Fuller, W.P. & Co., Calif (j)
General Extrusions, Inc., Ohio
(a)—Ad p 415
Harper, H. M. Co., Ill (b,f,g,h)
Harvey Aluminum, Calif (a,g,h)
Hawkridge Bros. Co., Mass (a)
Himmel Bros. Co., Conn (a)
Hunter Douglas Aluminum Div., Bridgeport Brass Co., Calif (a,b)
Huntington Alloy Products Div., International Nickel Co., Inc., W.Va (f)
Jarl Extrusions, Inc., NY
(a)—Ad p 426
Jasco Aluminum Products Co., NY (a)
Jet Specialties Co., Inc., Calif (k)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kassel Export Co., Inc., NJ (g)
Kawneer Co., Mich (a)
Kelsey-Hayes Co., Mich (g)
Kroh Wagner, Ill (a)
Langsenkamp, F.H. Co., Ind (a)
Light Metals Corp., Mich (a)
Magnode Products, Inc., Ohio (a,e)
Meier Brass & Aluminum Co., Mich (b)
Metal Goods Corp., Mo (a)
Metal Trims, Inc., Miss (a)
Moczik Tool & Die Works, Mich (a,b)
Monarch Tool & Mfg. Co., Ky (a)
Mueller Brass Co., Mich (a,b)
National Aluminum Co., Ohio (a)
National Lead Co., NY (a,b,d)
National Metal Products Co., Pa (a,b)
National Tube Div., U.S. Steel Corp., Pa (g)
New Jersey Aluminum Extrusion Co., Inc., NJ (a)
Nuclear Metals, Inc., Mass (a,b,c,e,f,g,h)
Olin Mathieson Chemical Corp., Metals Div., NY (a)
Parish Pressed Steel Div., Dana Corp., Pa (g)
Penn Brass & Copper Co., Pa (a)
Pfister Tubing Corp., NJ (a)
Phelps Dodge Copper Products Corp., NY
Pioneer Aluminum, Inc., Calif (a)
Pittsburgh Plate Glass Co., Pa (a,g)
Precision Extrusions, Inc., Ill
(a)—Ad p 430
Republic Metals Co., Inc., NY (d)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY
(a,b)—Ad p 153
Reynolds Aluminum Supply Co., Ga (a)
Reynolds Metals Co., Va (a)
Rockwell Engineering Co., Ill (a,b,c,g)
Royce Aluminum Corp., Mass (a)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
Saramar Aluminum Co., Ohio (a)
Scaife Co., Pa (a,c,f,g)
Scovill Mfg. Co., Conn (b)
Serrick Corp., Acme-Lees Div., Ind (a,g)
Southern Aluminum Finishing Co. Inc., Ga (a)

Southern Extrusions, Inc., Ark (a)
Stainless Metals, Inc., NY (g)
Steel Industries, Inc., Ind (b,g)
Superior Industries, Inc., Ohio (a)
Supplex Co., Div. of Amerace Corp., NJ (k)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (g)
Texas Aluminum Co., Inc., Tex (a)
Textron Metals Co., Ohio (a)
Thompson Products, Inc., Light Metals Div., Ohio (a)
Thompson Products, Inc., Valve Div., Ohio (f,g)
Titan Metals Mfg. Co. Div., Cerro Corp., Pa (b)
Titanium Metals Corp. of America, NY (h)
Toledo Stamping & Mfg. Co., Ohio (a,g)
Trim Alloys, Inc., Mass (a)
Union Steel Corp., NJ (g)
United Shoe Machinery Corp., Mass (f,g)
U.S. Extrusions Corp., NY (a)
U.S. Steel Corp., Pa (g)
U.S. Steel Supply Div., U.S. Steel Corp., Ill (a)
Universal Converting Corp., Mass (a)
Universal Screw Co., Ill (a,b,f,g,h)
Uniworld Research Corp. of America, Ohio (c)
Vulcan Metal Products, Inc., Ala (a)
Vulcan Rail & Construction Co., NY (a)
Vulcan-Kidd Steel Div., H.K. Porter Co., Inc., Pa (g)
W.F. Mfg. Co., Calif (a)
Warner Mfg. Corp., NJ (a)
Werner, R. D. Co., Pa (a)
Wesbar Stamping Corp., Wis (a,b,c,g)
White Metal Rolling & Stamping Corp., NY (a,e)
Whitehead Metal Products Co., Inc., NY (a)
Wolverine Tube, Div. of Calumet & Hecla, Inc., Mich (a)
Worcester Pressed Steel Co., Mass (a, g)
Youngstown Mfg., Inc., Ohio (a)

Extrusions, Nonmetallic

(excl. Tubing, Pipe)

Acadia Synthetic Products Div., Western Felt Works, Ill (m)
Ace Plastic Co., NY
(k)—Ad p 432
Allegheny Plastics, Inc., Pa (k)
Allied Resinous Products, Inc., Ohio (k)
Amco Plastic Pipe Co., Calif (k)
American Agile Corp., Ohio (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l,m)
American Molding Co., Calif (k)
American Plastics Corp., NY (k)
Anchor Plastics Co., Inc., NY (k)
Anesite Co., Ill (l)
Atlantic India Rubber Works, Inc., Ill (m)
Atlas Mineral Products Co., Pa (k)
Auburn Mfg. Co., Conn (k,m)
Auburn Plastics, Inc., NY (k,m)
Automotive Rubber Co., Inc., Mich (m)
Beck, I. & Sons, Inc., NY (m)
Bond International, Inc., Mich (m)
Borden Co., Borden Chemical Div., NY (k)
Bowling Green Rubber Co., Ohio (m)
Brown Rubber Co., Inc., Ind (m)
Button Corp. of America, NJ (k)
Byers, A.M. Co., Pa (k)
Cadillac Plastic & Chemical Co., Mich (k)
Cambridge-Panelyte Molded Plastics Co., Div. of St. Regis Paper Co., Ohio (k)
Campco Div., Chicago Molded Products Corp., Ill (k)
Canfield, H. O. Co., Va
Carlon Products Corp., Ohio (k)
Carolina Industrial Plastics Div., Essex Wire Corp., NC (k)
Celluplastic Corp., NJ (k)
Chardon Rubber Co., Ohio (k)
Colonial Plastics Mfg. Co., Div. of Van Dorn Iron Works Co., Ohio (k)
Conneaut Rubber & Plastics Co., Div. of U.S. Stoneware Co., Ohio
(k)—Ad p 413
Connecticut Hard Rubber Co., Conn (m)
Continental Rubber Works, Pa (m)
Contour Extrusion Co., NY (k)
Crane Plastics, Inc., Ohio
(k,m)—Ad p 430
Crescent Plastics, Inc., Ind (k)
Davis, Joseph Plastics Co., NJ (k)
Detroit Macoid Corp., Mich (k,m)
Dryden Rubber Div., Sheller Mfg. Co., Ill (m)
Eclipse Plastic Industries, Inc., Fla (k)
Electric Autolite Co., Ohio (k)
Eljay Corp., Md (l)
Enflo Corp., NJ (l)
Extruders, Inc., Calif (k)
Faultless Rubber Co., Ohio (m)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (m)
Frost Rubber Co., Ill (m)
Fry Plastics International, Calif (k)
Gallgher Co., Utah (k)
Garlock Packing Co., NY (k,m)
Geauga Industries Co., Ohio (k,m)
General American Transportation Corp., Ill (k)
General American Transportation Corp., Plastics Div., Ill (k)
General Electric Co., Chemical & Metallurgical Div., Ill (k)
General Gasket, Inc., Conn (m)
Gering Plastics, Div. of Studebaker-Packard Corp., NJ (k)
Gilman Bros. Co., Conn (k)
Glass Laboratories, Inc., NY (k)
Glass Reinforced Plastics Corp., Ohio (l)
Glastic Corp., Ohio (l)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Gossett and Hill Co., Ill (k)
Gotham Plastics Corp., NY (k)
Greene, Tweed & Co., Pa (m)
H & R Plastics Industries, Inc., Pa (k,m)
Hadbar, Inc., Calif (k,m)
Hall Mfg. Corp., NJ (k)
Hartwell, H.N. & Sons, Inc., Mass (k)
Haveg Industries, Inc., Del (l)
Hawkeye Rubber Mfg. Co., Iowa (m)
Hitemp Wires, Inc., NY (k)
Hungerford Plastics Corp., NJ (k,m)
Hydrawlik Co., NJ (k,m)
Industrial Plastics Corp., Ind (k)
Industrial Products Div., General Tire & Rubber Co., Ind (k)
Insulation Mfrs. Corp., Ill (k)
Irvington Varnish & Insulation Div., Minnesota Mining & Mfg. Co., NJ (k)
Jessall Plastics Div., Electric Storage Battery Co., Conn (k)
Jet Specialties Co., Inc., Calif (k)
Johnson Plastic Corp., Ohio (k,m)
Johnson Rubber Co., Ohio (m)
Jordan-Rogers Co., Calif (k)
Joymont Plastics, Inc., Ohio (k)
Judsen Rubber Works, Inc., Ill (m)
K S H Plastics, Inc., Mo (k)
Kaykor Industries, Inc., NJ (k)
Keystone Plastics, Inc., NJ (k)
Kraloy Plastic Pipe Co., Inc., Calif (k)
Lavelle Rubber Co., Ill (m)
Luminous Resins, Inc., Ill (k)
Lus-Trus Corp., Mich (k)
Luzerne Rubber Co., NJ (k,l)
Madin Plastics Inc., NJ (k)
Maloney, F.H. Co., Tex (k,m)
Markel, L. Frank & Sons, Pa (k,l,m)
Martin Rubber Co., Inc., NJ (m)
Mayon Plastics, Minn (k)
Mechanical Rubber Products Co., NY (l)
Meyer, J. & Sons, Inc., Pa (k)
Mid-States Rubber Products, Inc., Ind (m)
Midwest Plastic Products Co., Ill (k)
Minnesota Rubber Co., Minn (m)
Minnesota Rubber & Gasket Co., Minn (m)
Moldex, NY (m)
Moore, Samuel & Co., Ohio (k)
Moxness Products, Inc., Wis
(m)—Ad p 302
Mueller Brass Co., Mich (k)
Munray Products Div., Fanner Mfg. Co., Ohio (k)
National Gasket & Washer Mfg. Co., Inc., NY (k,l,m)
National Lock Co., Ill (k)
National Vulcanized Fibre Co., Del (k)
New England Tape Co., Div. of United-Carr Fastener Corp., Mass (k)
Olympic Plastics Co., Inc., Calif (k)
Owens Plastics Co., Mo (m)
Panelyte Div., St. Regis Paper Co., NJ (k)
Parker, Stearns & Co., Inc., NY (m)
Pawling Rubber Corp., NY (k,l)
Pennsylvania Fluorocarbon Co., Inc., Pa (k)
Perfex Plastics, Inc., Ill (k,m)
Pipco International Corp., Sub. of Plastiglide Mfg. Corp., Calif (k)
Plastex Co., Ohio (k)
Plastic Engineering, Inc., Ohio (k)
Plastic Packaging Co., Ill (k)
Plastiglide Mfg. Corp., Calif (k)
Plymouth Cordage Co., Mass (k)
Polyform Plastics Corp., NY (k)
Polygon Plastic Co., Ind (l)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa (k)
Poly Plastic Products, Inc., NJ (k)
Prince Rubber & Plastics Co., Inc., NY (k,l)
Pyramid Plastics, Inc., Ill (k)
Raybestos-Manhattan, Inc., NJ (k,l,m)
Reliance Plastic & Chemical Corp., NJ (k)
Rogers Corp., Conn (m)
Rowland Products, Inc., Conn (k)
Ryerson, Joseph T. & Son, Inc., Ill (k)
Schaefer-Hausner Corp., NY (k)
Schwab Plastic Corp., Mich (k,m)
Seamless Rubber Co., Conn (m)
Shamban, W.S. & Co., Ind (k)
Sheffield Plastics Co., Mass (k)
Sheller Mfg. Corp., Mich (k,l,m)
Sierra Engineering Co., Calif (m)
Southern Plastics Co., SC (k,m)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Stalwart Rubber Co., Ohio (m)
Standard Products Co., Mich (m)
Stockwell Rubber Co., Inc., Pa (k,m)
Sun Rubber Co., Ohio (m)
Sunlites Plastics, Inc., Wis (k)
Superior Plastics, Inc., Ill (k)
Supplex Co., Div. of Amerace Corp., NJ (k,m)
Taunton Div., Haveg Industries, Inc., Mass (k,m)
Technical Specialties Co., NY (m)
Textron Metals Co., Ohio (k)
Thermoid Div., H.K. Porter Co., Pa (k,m)
Thombert, Inc., Iowa (k)
Tri-Point Plastics, Inc., NY (k)
United Shoe Machinery Corp., Mass (k,m)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (k,l)
U.S. Rubber Co., Ind (l)
U.S. Stoneware Co., Ohio (k,l,m)
Victory Plastics Co., Mass (k)
Vogt Mfg. Co., NY (k)
Vulcanized Rubber & Plastics Co., Pa (m)
Western Felt Works, Ill (l,m)
Western Plastics Corp., Neb (k)
Western Textile Products Co., Mo (k,m)
Westlake Plastics Co., Pa (k)
Williams-Bowman Rubber Co., Ill (k, l)
World Plastics, NY (k)
Yale Rubber Mfg. Co., Mich (m)
Yardley Plastics Co., Ohio (k)

Fabrics, Nonwoven Synthetic

Albany Felt Co., NY
American Felt Co., Conn
—Ad p 307
Beckmann, Inc., NY
Booth Felt Co., Inc., NY
Cadillac Plastic & Chemical Co., Mich
Carborundum Co., Refractories Div., NJ
Chicopee Mills, Inc., NY
Chicopee Mills, Inc., Lumite Div., NY
Continental Felt Co., NY
—Ad p 318
Croname Inc., Ill
Dexter, C.H. & Sons, Inc., Conn
Duracote Corp., Ohio
Electrofilm Inc., Calif
Felters Co., Mass
—Ad p 302
Ferro Corp., Fiber Glass Div., Tenn
Filpaco Industries, Inc., Ill
Foss Mfg. Co., Id
Gustin-Bacon Mfg. Co., Mo
Kendall Co., Fiber Products Div., Mass
Masland Duraleather Co., Pa
National Felt Co., Mass
Quaker City Felt Co., Pa
Russell Mfg. Co., Conn
Snyder, M.L. & Son, Inc., Pa
Star Woolen Co., NY
Stevens, J.P. & Co., Inc., NY
Tallman-McCluskey Fabrics Co., Mo
Troy Blanket Mills, NY
—Ad p 317

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

U.S. Plywood Corp., NY
Vulcan Div., Reeves Bros., Inc., NY
Wellington Sears Co., NY
Wood Conversion Co., Minn

Fabrics, Woven
(coated)

Albany Felt Co., NY
Aldan Rubber Co., Pa
Alpha Wire Corp., NY
Buffalo Weaving & Belting Co., NY
Cadillac Plastic & Chemical Co., Mich
Chicago-Allis Mfg. Corp., Ill
Chicopee Mills, Inc., Lumite Div., NY
Connecticut Hard Rubber Co., Conn
Continental-Diamond Fibre Corp., Del
Cordo Chemical Corp., Conn
du Pont de Nemours, E. I. & Co., Inc., Del
Duracote Corp., Ohio
Fabricon Products Div., Eagle-Picher Co., Mich
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass
Flexible Tubing Corp., Minn
Foss Mfg. Co., Id
General Asbestos Gasket Mfg. Corp., Mo
General Plastics Corp., NJ
Goodrich, B.F. Industrial Products Co., Ohio
Huyck Corp., NY
Kaufman Glass Co., Del
Minnesota Mining & Mfg. Co., Missile Industry Liaison, Minn
—Ad p 367
Narmco Industries, Inc., Narmco Materials Div., Calif
National Gasket & Washer Mfg. Co., Inc., NY
Prince Rubber & Plastic Products Co., Inc., NY
Reeves Bros., Inc., Vulcan Div., NY
—Ad p 319
Royston Laboratories, Inc., Pa
Russell Mfg. Co., Conn
Schlegel Mfg. Co., NY
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio
Twitchell, E.W., Inc., Pa
Wasco Products, Inc., Mass
Wisconsin Gasket & Mfg. Co., Wis

Fabrics, Woven
(uncoated)

Aetna Felt Co., Inc., NY
Albany Felt Co., NY
Alox Mfg. Co., Mo
Alpha Wire Corp., NY
Atlantic Bag Co., NY
Booth Felt Co., Inc., NY
Buffalo Weaving & Belting Co., NY
Cadillac Plastic & Chemical Co., Mich
Chicopee Mills, Inc., Lumite Div., NY
Electrofilm, Inc., Calif
Ferro Corp., Fiber Glass Div., Tenn
Filpaco Industries, Inc., Ill
Foss Mfg. Co., Id
Franklin Cotton Mill Co., Ohio
General Asbestos Gasket Mfg. Corp., Mo
Huyck Corp., NY
National Gasket & Washer Mfg. Co., Inc., NY
Royston Laboratories, Inc., Pa
Russell Mfg. Co., Conn
Schlegel Mfg. Co., NY
Sherwatt Equipment & Mfg. Co., Inc., NY
Stevens, J.P. & Co., Inc., NY
Supreme Industrial Products Co., Ill
Tallman-McCluskey Fabrics Co., Mo
Thompson, H.I. Fiber Glass Co., Calif
Turner Halsey Co., NY
Twitchell, E.W., Inc., Pa
U.S. Rubber Co., NY
U.S. Rubber Co., Textile Div., NY
Vulcan Div., Reeves Bros., Inc., NY
Wellington Sears Co., NY

Fasteners
(see Mechanical Fasteners)

Felts, Synthetic
(see Fabrics, Nonwoven)

Felts, Wool

Aetna Felt Co., Inc., NY
Albany Felt Co., NY
American Felt Co., Conn
—Ad p 307
Armstrong Cork Co., Pa
Artex Felt Co., NY
Auburn Mfg. Co., Conn
Bacon Felt Co., Mass
Beckmann, Inc., NY
Booth Felt Co., Inc., NY
Boston Felt Co., Mass
Central Felt & Fabrics Corp., NY
Coated Abrasive Products, Inc., Ohio
Continental Felt Co., NY
—Ad p 318
Felters Co., Mass
—Ad p 322
Fidelity Felt & Mfg. Co., NY
Filpaco Industries, Inc., Ill
General Gasket, Inc., Conn
Hall, C. P. Co., NY
Huyck Corp., NY
Johns-Manville Corp., NY
Mechanical Felt & Textiles Co., NJ
National Felt Co., Mass
National Gasket & Washer Mfg. Co., Inc., NY
Quaker City Felt Co., Pa
Reynolds Aluminum Supply Co., Ga
Schlegel Mfg. Co., NY
Standard Asbestos Mfg. Co., Ill
Standard Felt Co., Calif
Supreme Industrial Products Co., Ill
Wellington Sears Co., NY
Western Felt Works, Ill
—Ad p 310
Wisconsin Gasket & Mfg. Co., Wis
Wood Conversion Co., Minn

Ferrites
(see Ceramics)

Fibers, Synthetic
(see specific polymer)

Filler Metals, Welding
(electrodes, rods, etc.)

Abalon Precision Mfg. Corp., NY
Acme Stamping & Wire Forming Co., Pa
Alloy Rods Co., Pa
All-State Welding Alloys Co., Inc., NY
Alofs Mfg. Co., Mich
Aluminum Co. of America, Pa
American Manganese Steel Div., American Brake Shoe Co., Ill
American Products Corp., Ill
Ampco Metal, Inc., Wis
Anaconda American Brass Co., NY
Arcos Corp., Pa
Atlas Foundry Co., Ohio
Bridgeport Brass Co., Conn
Champion Rivet Co., Ohio
Chicago Hardware Foundry Co., Ill
Dana Corp., Auburn Div., Ind
Electronic Parts Mfg. Co., Inc., NJ
Esco Corp., Ore
Eutectic Welding Alloys Corp., NY
General Dynamics Corp., Liquid Carbonic Div., Ill
Harnischfeger Corp., Wis
Hayden Wire Works, Inc., Mass
Haynes Stellite Co., Div. of Union Carbide Corp., NY
Huntington Alloy Products Div., International Nickel Co., Inc., W.Va
Ideal Can Co., Mass
Ingersoll Products Div., Borg-Warner Corp., Ill
Jervis Corp., Mich
K S M Products, Inc., NJ
Kaiser Aluminum & Chemical Sales, Inc., Ill
Lincoln Electric Co., Ohio
Linde Co., Div. of Union Carbide Corp., NY
—Ad p 349
Magnesium Products of Milwaukee, Inc., Wis
Magnesium Elektron, Inc., NY
Manganese Steel Forge Co., Pa
Marquette Mfg. Co. Div., Marquette Corp., Minn
McDowell Mfg. Co., Pa
Metal Goods Corp., Mo
Metals and Residues, Inc., NJ
Metal & Thermit Corp., NJ
Metals Engineering Corp., Tenn
Midwest Stamping & Mfg. Co., Ohio
Morrisville Foundry Co., Inc., Vt
Narragansett Boiler Works, Inc., RI
Noland Tank & Galvanizing Co., Tenn
Page Steel & Wire Div., American Chain & Cable Co., Pa
Rockwell Engineering Co., Ill
Schwarzkopf Development Corp., NY
Somerset Foundry & Machine Co., Pa
Southern Metal Products Co., La
Stoody Co., Calif
Stulz-Sickles Co., NJ
Titan Metal Mfg. Co. Div., Cerro Corp., Pa
Victor Equipment Co., Calif
Waimet Alloys Co., Mich
Wall Colmonoy Corp., Mich
Waterman Industries, Inc., Calif
Wesbar Stamping Corp., Wis
Whitehead Metal Products Co., Inc., NY

Film
(see specific plastic or rubber)

Fluorocarbon Plastics

aaRBee Plastic Co., Calif (y)
Acme Resin Corp., Ill (p)
Allegheny Plastics, Inc., Pa (bb,cc,dd,ee)
Allied Chemical Corp., Plastics Div., NY (t,y)
Auburn Plastic Engineering, Ill (t,bb,cc,dd,ee)
Automotive Rubber Co., Inc., Mich (y,cc)
Bamberger, Claude P., Inc., NJ (y)
Belding Corticelli Industries, NY (y)
Cadillac Plastic & Chemical Co., Mich (t,bb,cc,dd,ee)
Chemical Coatings & Engineering Co., Inc., Pa (x)
Chemco Products, Inc., RI (s,t,u,y,bb,cc,dd,ee)
Chicago Gasket Co., Ill (t,bb,cc,dd,ee)
Colonial Kolonite Co., Ill (bb,cc,dd,ee)
Comco Plastics, Inc., NY (bb,cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)
Conneaut Rubber and Plastics Co., Div. of U.S. Stoneware Co., Ohio (ee)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Crane Packing Co., Ill (t,bb,cc,dd,ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (bb,cc,dd,ee)
Dixon Corp., RI (y,bb,cc,dd,ee)
Dodge Fibers Corp., NY (s,t,cc,dd)
Doré, John L. Co., Tex (bb,cc,dd,ee)
du Pont de Nemours, E.I. & Co., Inc., Del
(p,s,t,y)—Ad p 217
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Enflo Corp., NJ (t,bb,cc,dd,ee)
Fluorocarbon Co., Calif (p,t,bb,cc,dd,ee)
Fluoro-Plastics, Inc., Div. of Flexrock Co., Pa (bb,cc,dd,ee)
Galigher Co., Utah (bb,cc,dd,ee)
Garlock Packing Co., NY
(y,bb,cc,dd,ee)—Ad p 269
General Gasket, Inc., Conn (t,cc)
General Plastics Corp., NJ (t,x)
General Plastics Mfg. Co., Wash (bb,cc,dd,ee)
Halogen Insulator & Seal Corp., Ill (bb,cc,dd,ee)
Haveg Industries, Inc., Del (bb,cc,ee)
Hitemp Wires, Inc., NY (ee)
Insulation Mfrs. Corp., Ill (t,bb,cc,dd,ee)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Kurz Kasch, Inc., Ohio (y)
Maloney, F.H. Co., Tex (y)
Minnesota Mining & Mfg. Co., Minn (y)
Minnesota Mining and Mfg. Co., Chemical Div., Minn (p,y)
Minnesota Mining & Mfg. Co., Missile Industry Liaison, Minn.
(p,y)—Ad p 367
Norrich Plastics Corp., NY (bb,ee)
Pennsalt Chemicals Corp., Pa
—Ad p 223
Pennsylvania Fluorocarbon Co., Inc., Pa (bb)
Permacel, NJ (t,cc,ee)
Plastic & Rubber Products Co., Calif (bb,cc,ee)
Polymer Corp., Pa
(t,bb,cc,dd,ee)—Ad p 264
Prince Rubber & Plastics Co., Inc., NY (bb,cc,ee)
Radiation Applications, Inc., NY (bb,cc,dd,ff)
Raybestos - Manhattan, Inc., Plastics Products Div., Pa
(bb,cc,ee)—Ad p 276
Resistoflex Corp., NJ (bb,cc,ee)
Russell Mfg. Co., Conn (s)
Sanford Plastics Corp., NY (bb,ee)
Shamban, W.S. & Co., Calif (p,t,x,y,bb,cc,dd,ee)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio
(t,y,bb,cc,dd,ee)—Ad p 400
Staver Co., Inc., NY (cc,dd)
Thombert, Inc., Iowa (bb,cc,dd,ee)
Tri-Point Plastics, Inc., NY (bb,cc,ee)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (t,bb,cc,dd,ee)
U.S. Stoneware Co., Ohio (ee)
Vulcan Div., Reeves Bros., Inc., NY (bb,dd,ee)
Westlake Plastics Co., Pa (t,y,bb,cc,dd,ee)

Fluorocarbon Rubber
(fluoroelastomers)

Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Bond International, Inc., Mich (y,ee)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chemical Coatings & Engineering Co., Pa (x,y)
Chicago-Allis Mfg. Corp., Ill (p)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio
(y,cc,dd)—Ad p 416
Connecticut Hard Rubber Co., Conn (cc,dd)
Continental Rubber Works, Pa (bb,cc,dd,ee)
Dayton Rubber Co., Ohio (y,bb,cc,dd,ee)
Dodge Fibers Corp., NY (s,t,cc,dd)
Dow Corning Corp., Mich (p)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E.I. & Co., Inc., Del (cc)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Flexible Tubing Corp., Conn (ee)
Garlock Packing Co., NY (y,cc)
Hadbar, Inc., Calif (y,bb,cc,dd,ee)
Hitemp Wires, Inc., NY (ee)
Hooker Chemical Corp., NY (p)
Insulation Mfrs. Corp., Ill (cc,dd)
Johns-Manville Corp., Dutch Brand Div., NY (cc)
Maloney, F.H. Co., Tex (y)
Minnesota Mining & Mfg. Co., Minn (p)
Minnesota Mining & Mfg. Co., Chemical Div., Minn (p,y)
Minnesota Mining & Mfg. Co., Missile Industry Liaison, Minn
(p,y)—Ad p 367
Moxness Products, Inc., Wis (cc)
Norrich Plastics Corp., NY (bb,dd,ee)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (y)
Rayclad Tubes, Inc., Calif (ee)
Rogers Corp., Conn
(u,y)—Ad pp 270-271

Roth Rubber Co., Ill (y,m)
Russell Mfg. Co., Conn (s)
Trostel, Albert Packing, Ltd., Wis (y)
Vulcan Div., Reeves Bros., Inc., NY (p,y,cc)
Western Felt Co., Ill (y,cc,dd,ee)
Westlake Plastics Co., Pa (bb,cc,dd)

Foams

(see specific plastic or rubber)

Foil

(see specific metal)

Forgings

(see also Cold Headed Parts)

Abegg & Reinhold Co., Calif (g)
Accurate Brass Corp., NY (b)
Albert Pipe Supply Co., Inc., NY (c,g)
Alco Products, Inc., NY (g)
Allegheny Ludlum Steel Corp., Pa (g)
Aluminium Ltd. Sales, Inc., NY (a)
Aluminum Co. of America, Pa (a,e)
Amalgamated Steel Corp., Ohio (g)
American Car & Foundry Div., ACF Industries, Inc., NY (g)
American Chain & Cable Co., Pa (g)
American Forge & Mfg. Co., Pa (g)
American Manganese Bronze Co., Pa (b)
American Metal Products Co., Mich (a,g)
American Steel Foundries, Ill (g)
Amforge Div., American Brake Shoe Co., Ill (a,g,h)
Ampco Metal, Inc., Wis (b)
Anaconda American Brass Co., NY (b)
Anti-Corrosive Metal Products Co., Inc., NY (g)
Armco Steel Corp., Sheffield Div., Mo (g)
Atlas Drop Forge Co., Mich (f,g,h)
Auld, D.L. Co., Ohio (a)
Avins Industrial Products Corp., NY (b)
Baldt Anchor, Chain & Forge Div., Boston Metals Co., Pa (a,b,g)
Baldwin-Lima-Hamilton Corp., Pa (g,h)
Bay City Forge Co., Pa (g)
Bethlehem Steel Co., Pa (g)
Billings & Spencer Co., Conn (a,b,g,h)
Bingham Herbrand Corp., Herbrand Div., Ohio (g)
Blakeslee Forging Co., Conn (a,b,c,d, f,g,h)
Bohn Aluminum & Brass Corp., Mich (a,b)
Braeburn Alloy Steel Corp., Pa (g)
Brewer-Titchener Corp., NY (a,g)
Bridgeport Brass Co., Conn (b,f)
Bristol Brass Corp., Conn (b)
California Drop Forge Co., Calif (g,h)
Cameron Iron Works, Inc., Special Products Div., Tex (c,f,g,h)—Ad p 417
Canton Forge & Axle Works, Poor & Co., Ohio (f,g)
Carbo Tool & Die Co., Ohio (c,f)
Carpenter Steel Co., Pa (g)
Champion Rivet Co., Ohio (b,c,g)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (a,b)
Chicago Extruded Metals Co., Ill (b)
Cincinnati Forging Co., Ohio (b)
Clapp, E.D. Mfg. Co., Inc., NY (b,c, f,g)
Cleveland Cap Screw Co., Ohio (a,b, f,g,h)
Cleveland City Forge Co., Ohio (a, c,f,g,h)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (g)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (g)
Columbus Bolt & Forging Co., Ohio (g)
Commercial Shearing & Stamping Co., Ohio (g)
Composite Forgings, Inc., Mich (g)
Consolidated Industries Inc., Conn (a, b,e,f,g,h)
Copper & Brass Sales, Inc., Mich (a,b)
Cored Forging Div., Bridgeport Brass Co., Conn (a,b)—Ad p 408
Crucible Steel Co. of America, Pa (g)
Curtiss-Wright Corp., Metals Processing Div., NY (a,b,f,g)
Custom Tool & Mfg. Co., Minn (c,f, g,h)
Cyril Bath Co., Ohio (a,g)
Dirilyte Co. of America, Inc., Ind (a,b,e)
Doehler-Jarvis Div., National Lead Co., Ohio (a)
Edgcomb Steel & Aluminum Corp., NJ (g)
Edgewater Steel Co., Pa (g,h)
Electric Autolite Co., Ohio (c)
Electric Materials Co., Pa (b)
Endicott Forging & Mfg. Co., Inc., NY (b,f,g,h)
Esco Corp., Ore (f,g)
Eureka Electric Products Inc., Pa (a, b,g)
Fairmount Tool & Forging, Inc., Sub. of Houdaille Industries, Inc., Ohio (g)
Finkl, A. & Sons Co., Ill (g)
Frasse, Peter A. & Co., Inc., NY (a,g)
Fromson Orban Co., Inc., NY (a)
Garden State Forge Co., NJ (a,b,c,f, g,h)
General Drop Forge Corp., NY (g)
Giant Grip Mfg. Co., Wis (a,g,h)
Greene, G.G. Corp., Pa (g)
Harrisburg Steel Co., NY (g)
Harvey Aluminum, Calif (a,c,g)
Heppenstall Co., Pa (g,h)
Hobbs, Clinton E. Co., Mass (c,g)
Hunter Corp., Pa (b,g,h)
Hunter-Douglas Aluminum Div., Bridgeport Brass Co., Calif (a,b)
Huron Forge & Machine Co., Mich (a,b,g)
Illinois Forge, Inc., Ill (g)
Illinois Iron & Bolt Co., Ill (g)
Indiana Forge & Machine Co., Ind (g)
Interstate Drop Forge Co., Wis (f,g)
Irwin-Sensenich Corp., Pa (a,g)
Isaacson Iron Works, Wash (g)
Janney Cylinder Co., Pa (b)
Jessop Steel Co., Pa (g)
Joslyn Pacific Co., Calif (g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kelsey-Hayes Co., Mich (g,h)
Keystone Forging Co., Pa (g)
Kropp Forge Co., Ill (g,h)
Ladish Co., Wis (a,b,c,e,f,g,h)
Larson, Charles E. & Sons, Inc., Ill (a,b,c,g)
Larson Tool & Stamping Co., Mass (a,b,c,e,f,g,h,j)
Latrobe Steel Co., Pa (g)
Lenape Hydraulic Pressing & Forging Co., Pa (a,b,g)—Ad p 422
Lindell Drop Forge Co., Mich (g)
Machinery Forging Co., Ohio (g)
Mallory, P.R. & Co., Inc., Ind (b)
Manganese Steel Forge Co., Pa (g)
McCarter Iron Works, Inc., Pa (g)
McInnes Steel Co., Pa (f,g,h)
McNally Pittsburg Mfg. Co., Kan (g)
Melling Forging Co., Mich (f)
Midvale-Heppenstall Co., Pa (c,f,g)
Milwaukee Forge & Machine Co., Wis (g)
Montague Machine Co., Mass (g)
Moore Dry Dock Co., Calif (g)
Mueller Brass Co., Mich (a,b)—Ad p 404
Murray, A.B. Co., Inc., NJ (a,b,f,g)
Murray Tube Works, Inc., NJ (a,b,g)
National Forge & Ordnance Co., Pa (g)
National Lead Co., NY (a,b,h)
National Supply Div., Armco Steel Corp., Pa (g)
National Tube Div., U.S. Steel Corp., Pa, (g)
Norcross, C.S. & Sons Co., Ill (g)
Ohio Forge & Machine Corp., Ohio (c,f,g)
Olderman Mfg. Corp., Conn (b)
Olds Alloys Co., Calif (b)
Pacific States Steel Corp., Calif (g)
Park Drop Forge Co., Ohio (g)
Pattin Mfg. Co., Ohio (g)
Pencoyd Steel & Forge Corp., Pa (c,g)
Peninsular Steel Co., Mich (g)
Pettibone Mulliken Corp., Ill (g)
Philadelphia Bronze & Brass Corp., Pa (a,b,f,h)
Phoenix Mfg. Co., Ill (g)
Pittsburgh Forgings Co., Pa (a,f,g)
Porter, H.K., Inc., Mass (g)
Porter, H.K., Inc., Forge & Fittings Div., Ohio (a,g)
Rankin Forge Co., Pa (c,g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (a,b)
Rhode Island Tool Co., RI (a,b,c,f,g)—Ad p 432
Rockford Bolt & Steel Co., Ill (g)
Rockwell Engineering Co., Ill (a,b,c,g)
Rome Mfg. Div., Revere Copper & Brass, Inc., NY (a,b)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
St. Pierre Chain Corp., Mass (a,f,g)
Scovill Mfg. Co., Mill Products Div., Conn (a,b)
Seltzer, George H. & Co., Pa (g)
Sherman & Reilly, Inc., Tenn (a,g)
Skookum Co., Inc., Ore (g)
Smith-Armstrong Forge, Inc., Ohio (g)
Standard Forge & Axle Co., Inc., Ala (g)
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (g)
Star Heel Plate Co., Inc., NJ (g)
Steel, R. & Sons, Inc., NY (f,g)
Steel Improvement and Forge Co., Ohio (b,f,g,h)
Struthers Wells Corp., NY (f,g)
Taylor Forge & Pipe Works, Ill (a,c, f,g,h)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (g)
Thompson Products, Inc., Valve Div., Ohio (f,g)
Titan Metal Mfg. Co. Div., Cerro Corp., Pa (a,b)
Tool & Mfg. Co., Inc., Pa (g)
Transue & Williams Steel Forging Corp., Ohio (b,c,f,g,h)
Tube Turns, Div. of Chemetron Corp., Ky (a,b,c,e,f,g,h)
Union Forging Co., NY (g)
United Forge Co., Mich (c,g)
United Shoe Machinery Corp., Mass (a)
U.S. Steel Corp., Pa (g)
Universal-Cyclops Steel Corp., Pa (f,g)
Uniworld Research Corp. of America, Ohio (c)
Vanadium-Alloys Steel Co., Pa (g)
Vulcan-Kidd Steel Div., H.K. Porter Co., Inc., Pa (g)
Walker Forge, Inc., Wis (g)
Weatherhead Co., Ind (a,b,g,h)
Weber-Knapp Co., NY (a)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (a,b,c,f,g,h)
Wilcox Forging Corp., Pa. (c,f,g,h)
Wilde Drop Forge & Tool Co., Inc., Mo (g)
Wilde Tool Co., Inc., Kan (g)
Williams, J.H. & Co., NY (a,b,e,f,g,h)
Wyman-Gordon Co., Mass (a,e,f,g,h)
Zeller Corp., Ohio (g)
Ziv Steel & Wire Co., Ill (g)

Forsterite

(see Ceramics)

Furanes

Adhesive Products Corp., NY (x)
Alcylite Plastics & Chemical Corp., Calif (p)
Atlas Mineral Products Co., Pa (p,x)
Durez Plastics Div., Hooker Chemical Corp., NY (p)
Electro Chemical Engineering & Mfg. Co., Pa (cc)
Foss Mfg. Co., Id (x)
Furane Plastics, Inc., Calif (p,x)
Haveg Industries, Inc., Del (p,bb,cc, ee)
Knight, Maurice A. Co., Ohio (p,x)
Permaspray Mfg. Co., Tex (p,cc,dd)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Reichhold Chemicals, Inc., NY (p)
U.S. Stoneware Co., Ohio (y)

Galvanized Metals

(see Precoated Metals)

Galvanizers

Acme Galvanizing Co., Calif
Advance Galvanizing Co., Calif
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich
American Smelting & Refining Co., NY
American Tinning & Galvanizing Co., Pa
Armco Steel Corp., Ohio
Armor Galvanizing Works, Inc., Calif
Atlantic Steel Co., Ga
Atlas Galvanizing Co., Calif
Bessemer Galvanizing Works, Ala
Bethlehem Steel Co., Pa
Boyles Galvanizing & Plating Co., Tex
Buffalo Steel Corp., NY
Byers, A.M. Co., Pa
Clayton & Lambert Mfg. Co., Ky
Clifton Conduit Corp., Md
Columbian Steel Tank Co., Mo
Continental-Emsco Co., Calif
Debevoise Co., NY
Designers Metal Corp., Ill

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Detroit Brass & Malleable Co., Mich
Dow Chemical Co., Tex
Empire Metal Co., NY
Enterprise Galvanizing Co., Pa
Fanner Mfg. Co., Ohio
Farrelloy Co., Pa
Fenestra, Inc., Mich
Galvicon Corp., NY
General Chain & Mfg. Corp., Ohio
Green-Walker Galvanizing Co., Inc., La
Gregory, Thomas Galvanizing Works, NY
Hanlon-Gregory Galvanizing Co., Pa
Haywlk Galvanizing, Inc., La
Hill, James Mfg. Co., RI
Illinois Edison Porcelain Div., McGraw-Edison Co., Ill
Independent Galvanizing Co., NJ
Joslyn Mfg. & Supply Co., Ill
Joslyn Pacific Co., Calif
Kent County Galvanizing Co., RI
Kinkead Industries, Inc., Ill
Kobel, W.R. Sheet Metal Products, Utah
Kovea, L.O. & Bro., Inc., NJ
Lawson, F.H. Co., Ohio
Lehigh Structural Steel Co., Pa
Lewis Bolt & Nut Co., Minn
Line Material Industries, McGraw-Edison Co., Pa
Los Angeles Galvanizing Co., Calif
Malleable Iron Fittings Co., Conn
Maze, W.H. Co., Ill
Metal Coating Corp., Ill
Metallizing Co. of Los Angeles, Inc., Calif
Metalplate Co., Inc., Ala
Missouri Rolling Mill Corp., Miss
National Galvanizing Co., Pa
National Gasket & Washer Mfg. Co., Inc., NY
New Jersey Zinc Co., NY
Noland Tank & Galvanizing Co., Tenn
Northwestern Steel & Wire Co., Ill
Nowery J. Smith Bolt & Supply Co., Tex
Nylok Corp., NJ
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa
Penn Metal Co., Inc., W.Va
Pittsburgh Steel Co., Pa
Reed & Prince Mfg. Co., Mass
Republic Steel Corp., Ohio
Riverside Foundry & Galvanizing Co., Mich
Roebling's, John A. Sons Div., Colorado Fuel & Iron Corp., NJ
Rohaco, Inc., Ill
Ryerson, Joseph T. & Son, Inc., Ill
San Francisco Galvanizing Works, Calif
Sawhill Tubular Products, Inc., Pa
Scaife Co., Pa
Schlueter Mfg. Co., Mo
Sealube Co., Mass
Sharon Steel Corp., Pa
Sherman & Reilly, Inc., Tenn
Smith, N.J. Bolt Co., Tex
Southern Galvanizing Co., Md
Southern Metal Products Co., La
Spencer Nahm Co., Calif
Spring City Foundry Co., Pa
Stevens, Frederic B., Inc., Mich
Superior-Pacific Galvanizing Co., Calif
Trenton Pipe Nipple Co., NJ
WLS Stamping Co., Ohio
Wessels Co., Mich
Wilcox-Crittenden Div., North & Judd Mfg. Co., Conn
Witt Cornice Co., Galvanizing Div., Ohio
Wood, John Co., Ill
Young & Greenawalt, Ind

Germanium

African Metals Corp., NY (w)
American Metal Climax, Inc., NY (o,w,aa)
American Zinc Sales Co., Mo (q)
Belmont Smelting & Refining Works, Inc., NY (aa)
Eagle-Picher Co., Ohio (w,aa)
Hardy, Charles, Inc., NY (aa)
New Jersey Metals Co., NJ (o)
Parker Metal Goods Co., Mass (bb)
Sylvania Electric Products, Inc., Chemical & Metallurgical Div., Pa (w)

Ullmann, Inc., Wis (o,ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)

Glass, Alumino-Silicate

Bassichis Co., Ohio (aa)
Bausch & Lomb Inc., NY (r,s)
Bird, Richard H. Co., Inc., Mass (r)
Corning Glass Works, NY (r,bb,cc,ee)—Ad p 321
Electro-Ceramics, Inc., Utah (r,bb,cc,ee)
Fischer & Porter Co., Pa (r)
Kaufman Glass Co., Del (z,bb,cc,ee)
Kimble Glass Co., Sub. of Owens-Illinois Glass Co., Ohio (r,aa,bb,ee)
Kopp Glass, Inc., Pa (r)—Ad p 311
Lancaster Glass Corp., Ohio (r)
Pittsburgh Plate Glass Co., Pa (s)
Russell Mfg. Co., Conn (r,s)
Wilmad Glass Co., Inc., NJ (r)

Glass, Borosilicate

Anchor Hocking Glass Corp., Ohio (r)
Applied Instruments, Inc., NY (z,bb,cc,ee)
Bassichis Co., Ohio (aa)
Bausch & Lomb Inc., NY (r,s)
Bird, Richard H. Co., Mass (r)
Corning Glass Works, NY (r,z,aa,bb,cc,ee)—Ad p 321
Fischer & Porter Co., Pa (r)
Fish-Schurman Corp., NY (r)
Friedrich & Dimmock, Inc., NJ (r,s)
Gustin-Bacon Mfg. Co., Mo (r,s)
Johns-Manville Corp., NY (s)
Kaufman Glass Co., Del (z,bb,cc,ee)
Kimble Glass Co., Sub. of Owens-Illinois Glass Co., Ohio (r,aa,bb,ee)
Kopp Glass, Inc., Pa (r)—Ad p 311
Lancaster Glass Corp., Ohio (r)
Mansol Ceramics Co., NJ (r,aa)
Marsco Mfg. Co., Ill (r)
Modiglass Fibers, Inc., NJ (s)
Penberthy Instrument Co., Wash (r)
Pfaudler Co., NY
Pittsburgh Corning Corp., Pa (u)
Pittsburgh Plate Glass Co., Pa (s)
Pittsburgh Plate Glass Co., Fiber Glass Div., Pa (s)
Russell Mfg. Co., Conn (s)
Semon Bache & Co., NY (z,cc,ee)
Shull Bros. Glass Co., NJ (r,ee)
Thompson, H.I. Fiber Glass Co., Calif (s)

Glass, Lead Alkali Silicate

Bassichis Co., Ohio (aa)
Bausch & Lomb Inc., NY (r,s)
Corning Glass Works, NY (r,aa,bb,ee)—Ad p 321
Fischer & Porter Co., Pa (r)
Kaufman Glass Co., Del (z,bb,cc,ee)
Kimble Glass Co., Sub. of Owens-Illinois Glass Co., Ohio (r,aa,bb,ee)
Kopp Glass, Inc., Pa (r)—Ad p 311
Lancaster Glass Corp., Ohio (r)
Mansol Ceramics Co., NJ (r,aa)
Pemberthy Instrument Co., Wash (r,z)
Semon Bache & Co., NY (z,cc,ee)

Glass, 96% Silica

Amersil Quartz Div., Engelhard Industries, Inc., NJ (s,z,aa,bb,cc,ee)
Applied Instruments, Inc., NY (z,cc,ee)
Bassichis Co., Ohio (aa)
Bausch & Lomb Inc., NY (r,s)
Corning Glass Works, NY (r,z,aa,bb,cc,ee)—Ad p 321
Fischer & Porter Co., Pa (r)
Johns-Manville Corp., NY (s)
Kaufman Glass Co., Del (z,bb,cc,ee)
Marsco Mfg. Co., Ill (r)
Russell Mfg. Co., Conn (r,s)
Saunders, Alexander & Co., Inc., NY (aa)

Thompson, H.I. Fiber Glass Co., Calif (s)

Glass, Silica

Applied Instruments, Inc., NY (z,cc,ee)
Bassichis Co., Ohio (aa)
Bausch & Lomb Inc., NY (r,s)
Corning Glass Works, NY (r,cc)—Ad p 321
Fischer & Porter Co., Pa (r)
Friedrich & Dimmock, Inc., NJ (r)
Johns-Manville Corp., NY (s)
Kaufman Glass Co., Del (z,bb,cc,ee)
McGean Chemical Co., Ohio
Modiglass Fibers, Inc., NJ (s)
Pittsburgh Corning Corp., Pa (u)
Pyrosil, Inc., Ohio (r,z,aa,bb,cc,ee)
Semon Bache & Co., NY (z,cc,ee)
Thermal American Fused Quartz Co., NJ (r,z,bb,cc,ee)
Thompson, H.I. Fiber Glass Co., Calif (s)

Glass, Soda-Lime

Anchor Hocking Glass Co., Ohio (r)
Applied Instruments, Inc., NY (z,bb,cc,ee)
Bassichis Co., Ohio (aa)
Bausch & Lomb Inc., NY (r,s)
Corning Glass Works, NY (r,aa,bb,ee)—Ad p 321
Erie Scientific Corp., NY (cc)
Fischer & Porter Co., Pa (r)
Friedrich & Dimmock, Inc., NJ (r,s,bb,ee)
Kaufman Glass Co., Del (z,bb,cc,ee)
Kimble Glass Co., Sub. of Owens-Illinois Glass Co., Ohio (r,aa,bb,ee)
Kopp Glass, Inc., Pa (r)—Ad p 311
Lancaster Glass Corp., Ohio (r)
Mansol Ceramics Co., NJ (r,aa)
Modiglass Fibers, Inc., NJ (s)
Pittsburgh Plate Glass Co., Pa (z,cc)
Semon Bache & Co., NY (z,cc,ee)
Shull Bros. Glass Corp., NJ (r,bb,ee)
Thompson, H.I. Fiber Glass Co., Calif (s)

Glass Coatings

(see Inorganic Coatings)

Glass for Plastics Reinforcement

American Polyglas Corp., NJ
Bassichis Co., Ohio
Coast Mfg. & Supply Co., Calif
Electrofilm, Inc., Calif
Exeter Mfg. Co., NY
Famco, Inc., Ky
Ferro Corp., Ohio
Ferro Corp., Fiber Glass Div., Tenn
Flexfirm Products, Calif
Foss Mfg. Co., Id
Glass Textiles Div., Johns-Manville Corp., Ohio
Miller-Stephenson Chemical Co., Inc., Conn
Modiglass Fibers, Inc., NJ
Owens-Corning Fiberglas Corp., Ohio
Pittsburgh Plate Glass Co., Fiber Glass Div., Pa —Ad p 313
Pyrosil, Inc., Ohio
Ren Plastics, Inc., Mich
Rezolin, Inc., Calif
Riegel Paper Corp., NY
Russell Mfg. Co., Conn
Schramm Fiberglass Products, Inc., Ill
Standard Insulation Co., Plastics Div., NJ
Stevens, J.P. & Co., Inc., NY
Tallman-McCleskey Fabrics Co., Mo
Thompson, H.I. Fiber Glass Co., Calif
Union Carbide Metals Co., Div. of Union Carbide Corp., NY

Gold and Its Alloys

Advance Stamping Co., Mich (dd)
Alpha Metals, Inc., NJ
American Metal Climax, Inc., NY (w,aa)

American Platinum & Silver Div., Engelhard Industries, Inc., NY (n,o,v,z,bb,cc,dd,ee,ff)
American Platinum Works, NJ (z)
American Silver Co., NY (v,dd,ee,ff)
American Smelting & Refining Co., NY (o)
Anaconda Co., NY (o)
Anchor Metal Co., Inc., NY (w)
Baker & Co., Inc., NJ (n,o,v,w,z,bb,cc,dd)
Bart Mfg. Corp., NJ (aa)
Bishop, J. & Co. Platinum Works, Pa (v,ff)
Composite Industrial Metals, Inc., RI (n)
Deringer Metallurgical Corp., Ill (cc,dd,ee,ff)
Eastern Smelting & Refining Corp., Mass (n,o,v,w,z,aa,bb,cc,dd,ee,ff)
Goldsmith Bros. Div., National Lead Co., Ill (n,o,v,w,z,aa,bb,cc,dd,ff)
Hagstoz, T.B. & Son, Pa (n,cc,dd,ff)
Handy & Harman, NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Hanovia Chemical & Mfg. Co., NJ (aa)
Hardy, Charles, Inc., NY (aa)
Hastings & Co., Inc., Pa (v)
Hayden Wire Works, Inc., Mass (ff)
Horton-Angell Co., Mass (n,o,bb,cc,dd,ee,ff)
Improved Seamless Wire Co., RI (bb,cc,dd,ee,ff)
Jelenko, J. F. Co., Inc., NY (z,bb,cc,dd,ff)
Lakeland Industries, Minn (z)
Leach & Garner Co., Industrial Div., Mass (n,o,v,z,bb,cc,dd,ee,ff)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (n,o,v,z,bb,dd,ee,ff)
Metals Disintegrating Co. Div., American-Marietta Co., NJ (aa)
Metz Refining Co., NJ (n,o,q,z,aa,bb,cc,dd,ee,ff)
Michelman Chemicals, Inc., Ohio
Nesor Alloy Products Co., NJ (dd,ff)
Ney, J.M. Co., Industrial Div., Conn (v,z,bb,cc,dd,ee,ff)
Norwalk Powdered Metals, Inc., Conn (aa)
Peerless Roll Leaf Co., Div. of Howe Sound Co., NJ (v,dd)
Riegel Paper Corp., NY
Sel-Rex Corp., NJ (n,aa)
Standard Metals Corp., Mass (n,o,v,z,bb,cc,dd,ee,ff)
Technic, Inc., RI (aa)
Texas Instruments, Inc., Metals & Controls Div., Mass (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif (aa,cc,dd,ff)
Wildberg Bros. Smelting & Refining Co., Calif (n,o,v,w,z,aa,bb,cc,dd,ff)
Williams Gold Refining Co., Inc., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)

Graphite

(see Carbon)

Gray Iron

(see Iron)

GR-S Rubber

(see Styrene-Butadiene Rubber)

Hard Facing Alloys

Air Reduction Sales Co., Div. of Air Reduction Co., Inc., NY
Alloy Rods Co., Pa
Alloy Surfaces Co., Inc., Del
All-State Welding Alloys Co., Inc., NY
American Brake Shoe Co., NY
American Manganese Steel Div., American Brake Shoe Co., Ill
American Smelting & Refining Co., NY
Champion Rivet Co., Ohio
Cleveland Hard Facing Co., Inc., Ohio
Coast Metals, Inc., NJ
Crucible Steel Co. of America, Pa
Esco Corp., Ore

Fabriform Metal Brazing, Calif
General Electric Co., NY
Harnischfeger Corp., Wis
Hayden Wire Works, Inc., Mass
Haynes Stellite Co., Div. of Union Carbide Corp., NY
Hobart Bros. Co., Ohio
Hunter Corp., Pa
Janney Cylinder Co, Pa
Kennametal, Inc., Pa
Kinkead Industries, Inc., Ill
Lincoln Electric Co., Ohio
Marquette Mfg. Co. Div., Marquette Corp., Minn
McKay Co., Pa
Metal Finishers, Inc., Md
Metal & Thermit Corp., NJ
Metal-Cladding, Inc., NY
Metallizing Co. of Los Angeles Inc., Calif
Metco Inc., NY
Moore Drydock Co., Calif
Morrisville Foundry Co., Inc., Vt
Overmyer Mould Co., Inc., Ind
Pabst Engineering Equipment Co., Inc., NJ
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa
Plasmatech Div., Valley Metallurgical Processing Co., Conn
Republic Steel Corp., Ohio
Sommer Metalcraft Corp., Ind
Stevens, Frederic B., Inc., Mich
Stoody Co., Calif
Tiarco Corp., NJ
Uniworld Research Corp. of America, Ohio
Vanadium-Alloys Steel Co., Pa
Victor Equipment Co., Calif
Wall Colmonoy Corp., Mich

Hard Surfaces for Metals

(see Diffusion Coatings; Hard Facing Alloys)

High Pressure Laminates

(see Laminates)

Hot Melt Coatings

(see Organic Coatings)

Hypalon

(see Chlorosulfonated Polyethylene Rubber)

Immersion Coatings, Chemical

(incl. Electroless)

Allied Research Products, Inc., Md
Amchem Products, Inc., Pa
Automotive Rubber Co., Inc., Mich
Biddle Screw Products Co., Ind
Birchwood Chemical Co., Minn
Carboline Co., Mo
Chemical Development Corp., Mass
Cowles Chemical Co., Ohio
Dollin Corp., NJ
Electro Chemical Engineering & Mfg. Co., Pa
Engineering Products & Specialties, Inc., RI
Hughson Chemical Co., Div. of Lord Mfg. Co., Pa
Industrial Chromium Corp., Mass
Jervis Corp., Mich
Kanigen Div., General American Transportation Corp., Ill
Lewco, Ohio
Lithcote Corp., Ill
MacDermid, Inc., Conn
Mariane Development Co., Inc., NY
Merix Chemical Co., Ill
Metal Finishers, Inc., Md
Metal & Thermit Corp., NJ
Metal-Cladding, Inc., NY
Mitchell-Bradford Chemical Co., Conn
Modern Plating Corp., Ill
National Lock Co., Ill
Neilson Chemical Co., Mich
Nuclear Materials & Equipment Corp., Pa
Nylok Corp., NJ
Oakite Products, Inc., NY
Octagon Process, Inc., NY
Parker Rust Proof Co., Mich
Plume & Atwood Mfg. Co., Conn
Reynolds Chemical Products Co., Mich
Rustproofing & Metal Finishing Corp., Mass
St. Eloi Corp., Ohio
Sealube Co., Mass
Stevens, Frederic B., Inc., Mich
Superior Plating, Inc., Minn
Tuff Clad, Inc., Ohio
Turco Products, Inc., Calif
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
Wall Colmonoy Corp., Mich
WLS Stamping Co., Ohio
Wright Metalcoaters, NJ

Impact Extrusions

(cold extrusions)

Allied Products Corp., Mich (g)
Almco Steel Products Corp., Ind (b,g)
Aluminum Co. of America, Pa (a)
Bridgeport Brass Co., Conn (a)
Cliff Mfg. Co., Ohio (a)
Curtiss-Wright Corp., NY (g)
Cyril Bath Co., Ohio (g)
Division Lead Co., Ill (d)
Dow Chemical Co., Mich (a,e)
Fletcher Enamel Co., W.Va (a,b,c,d,e,f)
Fromson Orban Co., Inc., NY (a)
Harvey Aluminum, Calif (a)
Heintz Div., Kelsey-Hayes Co., Pa (g)
Hunter Corp., Pa (a,b,g,h)
Hunter-Douglas Aluminum Div., Bridgeport Brass Co., Calif (a)
Impact Extrusions, Inc., Ind (a)
Impax, Inc., Mo (a,b,e,j)
Jervis Corp., Mich (a)
Ladish Co., Wis (a,b,c,e,f,g,h)
Leake Engineering Co., Mich (a,b,d,g)
Magline, Inc., Mich (e)
Mueller Brass Co., Mich
(a,b,g)—Ad p 404
National Impacted Metal Corp., Miss (a,b,e,j)
Republic Steel Corp., Ohio (g)
Rockwell-Standard Corp., Stamping Div., NY (a,g)
Rome Mfg. Div., Revere Copper & Brass, Inc., NY (a,b)
Sherman & Reilly, Inc., Tenn (e,f,g)
Sun Tube Corp., NJ (a,b,e)
Thompson Products, Light Metals Div., Ohio (a)
Townsend Co., Engineered Fasteners Div., Pa (a,b,g)
United Shoe Machinery Corp., Mass (a)
Universal Screw Co., Ill (a,b,f,g,h)
Westinghouse Electric Corp., Materials Mfg. Corp., Pa (b,f,g)
Wirz, A.H., Inc., Pa (a,b,d,j)
Worcester Pressed Steel Co., Mass (a)

Impregnated or Compressed Wood

(see Wood)

Impregnation Coatings

(see Organic Coatings)

Indium and Its Alloys

Alpha Metals, Inc., NJ (o,q,w,bb,cc,dd)
American Silver Co., NY (v,dd,ee,ff)
American Smelting & Refining Co., NY (n,o,q,v,w,bb,cc,dd,ff)
Anaconda Co., NY (aa)
Belmont Smelting & Refining Works, Inc., NY (o)
Cerro Sales Corp., Sub. of Cerro Corp., NY
(o,w)—Ad p 154
Division Lead Co., Ill (o,v,cc,ff)
Empire Metal Co., NY (n,o,q,w,bb,ff)
Federated Metals Div., American Smelting and Refining Co., NY (o,q,v,w,bb,cc,dd,ff)
Goldsmith Bros. Div., National Lead Co., Ill (o,q)
Handy & Harman, NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Hardy, Charles, Inc. NY (aa)
Indium Corp. of America, NY
(n,o,q,v,w,z,aa,bb,cc,dd,ff) — Ad p 154
International Minerals and Metals Corp., NY (w)
Kelsey-Hayes Co., Utica Metals Div., NY (w)
Nesor Alloy Products Co., NJ (dd,ff)
Sel-Rex Corp., NJ (aa)
Texas Instruments, Inc., Metals & Controls Div., Mass (dd)
United Refining & Smelting Co., Ill (n,o,q,w,z,bb,cc,dd,ff)
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif (dd, ff)

Ingots

(see specific metal)

Injection Moldings

(see Moldings)

Inorganic Coatings, Ceramic

(formulations)

Bisonite Co. Inc., NY
California Metal Enameling Co., Calif
Chicago Vitreous Corp., Div. of Eagle-Picher Co., Ill
Continental Coatings Corp., Ohio
Cooley, W.J. & Co., Tenn
Dennis Chemical Co., Mo
Douglas & Sturgess, Calif
du Pont de Nemours, E.I. & Co., Inc., Del
Dyna-Therm Chemical Corp., Calif
Earl Paint Corp., NY
Electrolizing Co., Ill
Erie Enameling Co., Pa
Harshaw Chemical Co., Ohio
Hayden Wire Works, Inc., Mass
Hitemp Wires, Inc., NY
Hommel, O. Co., Pa
Ingram-Richardson, Inc., Ind
Kraus Research Labs, Md
Laboratory Equipment Corp., Mich
Lithium Corp. of America Inc., Minn
Metal & Thermit Corp., NJ
Metallizing Engineering Co., Inc., NY
Norton Co., Mass
—Ad p 347
Nuclear Materials & Equipment Corp., Pa
Refractory & Insulation Corp., NY
Sauereisen Cements Co., Pa
Solar Aircraft Co., Calif
Thermal Refractories Corp., NJ
Zirconium Corp. of America, Ohio

Inorganic Coatings, Ceramic

(coaters)

American Emblem Co., Inc., NY
Bevan Co., Calif
Bisonite Co., Inc., NY
Brooks & Perkins, Inc., Mich
California Metal Enameling Co., Calif
Chromium Corp. of America, NY
Continental Coatings Corp., Ohio
Cooley, W.J. & Co., Tenn
Custom Tool & Mfg. Co., Minn
Dyna-Therm Chemical Corp., Calif
Electrofilm, Inc., Calif
Electrolizing Co., Ill
Emerson & Cuming, Inc., Mass
Enamel Products Co., Ohio
Erie Ceramic Arts Co., Pa
Erie Enameling Co., Pa
Fletcher Enamel Co., W.Va
Galigher Co., Utah
General Plastics Corp., NJ
Hayden Wire Works, Inc., Mass
Ingram-Richardson, Inc., Ind
Lancaster Glass Corp., Ohio
Lansdale Porcelain Enamel Corp., Pa
Metal-Cladding, Inc., NY
Metallizing Co. of Los Angeles, Inc., Calif
Metaplast Process, Inc., NY
Norton Co., Mass
—Ad p 347
Nuclear Materials & Equipment Corp., Pa
Pabst Engineering Equipment Co., Inc., NJ
Plasmatech Div., Valley Metallurgical Processing Co., Conn
Porcelain Enamel Finishers, Ill
Russell Mfg. Co., Conn
St. Eloi Corp., Ohio
Solar Aircraft Co., Calif
Swedlow, Inc., Calif
Sylvester & Co., Ohio
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
Zirconium Corp. of America, Ohio

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Inorganic Coatings, Porcelain or Glass

(formulations)

American Metal Products Co., Mich
Bettinger Corp., Mass
California Metal Enameling Co., Calif
Chemical Coatings and Engineering Co., Pa
Chicago Vitreous Corp., Div. of Eagle-Picher Co., Ill
Dennis Chemical Co., Mo
Du-Co Ceramics Co., Pa
du Pont de Nemours, E.I. & Co., Inc., Del
Dyna-Therm Chemical Corp., Calif
Erie Ceramic Arts Co., Pa
Erie Enameling Co., Pa
Ferro Corp., Ohio
Harshaw Chemical Co., Ohio
Hitemp Wires, Inc., NY
Hommel, O. Co., Pa
Independence Stove & Mfg. Co., Mo
Ingram-Richardson, Inc., Ind
Lithium Corp. of America Inc., Minn
Metal-Cladding Inc., NY
Pemco Corp., Md
Pierce & Stevens Chemical Corp., NY
Sauereisen Cements Co., Pa
Wyandotte Chemicals Corp., Mich

Inorganic Coatings, Porcelain or Glass

(enamelers)

AllianceWall Div., AllianceWare, Inc., Ohio
American Valve & Enameling Corp., Ind
Applied Instruments, Inc., NY
Barrows Porcelain Enamel Corp., Ohio
Bettinger Corp., Mass
Bevan Co., Calif
California Metal Enameling Co., Calif
Chicago Hardware Foundry Co., Ill
Cleveland Porcelain Enameling Co., Ohio
Emerson & Cuming, Inc., Mass
Enamel Products Co., Ohio
Erie Ceramic Arts Co., Pa
Erie Enameling Co., Pa
Ervite Co., Pa
Ferro Enameling Co., Calif
Fletcher Enamel Co., W.Va
Geuder, Paeschke & Frey Co., Wis
Hamilton Die Cast, Inc., Ohio
Independence Stove & Mfg. Co., Mo
Ingersoll Products Div., Borg-Warner Corp., Ill
Ingram-Richardson, Inc., Ind
Ingram-Richardson Mfg. Co., Pa
Kawneer Co., Mich
Lansdale Porcelain Enamel Corp., Pa
Metal & Thermit Corp., NJ
Metal-Cladding, Inc., NY
Monarch Aluminum Mfg. Co., Ohio
National Metal Products Co., Pa
Penn Fibre & Specialty Co., Inc., Pa
Philadelphia Enameling Works, Inc., Pa
Pittsburgh Plate Glass Co., Pa
Porcelain Enamel Finishers, Ill
Scaife Co., Pa
Seaporcel Metals, Inc., NY
Smith, A.O. Corp., Wis
Smoot-Holman Co., Calif
Southwestern Porcelain Steel Corp., Okla
Swedlow, Inc., Calif
Temco, Inc., Tenn
Vollrath Co., Wis

Inorganic Fibers

(except Asbestos, Ceramic, Glass, Carbon; see these categories)

Allied Chemical Corp., Plastics Div., NY
Baldwin-Ehret-Hill, Inc., NJ
Carborundum Co., NY
Carey, Philip Mfg. Co., Ohio
Celotex Corp., Ill
Eagle-Picher Co., Ohio
Electrofilm Inc., Calif
Gustin-Bacon Mfg. Co., Mo
Johns-Manville Corp., NY
Modiglass Fibers, Inc., NJ
Standard Asbestos Mfg. Co., Ill
Thermal Refractories Corp., NJ
Union Carbide Metals Co., Div. of Union Carbide Corp., NY

Intermetallic Compounds

(see Ceramics; Refractories)

Investment Castings

(see castings)

Iron, Alloy

(castings)

Acme Foundry & Machine Co., Okla
Adirondack Steel Casting Co., NY
Advance Foundry Co., Ohio
Albert Lea Foundry Co., Minn
Albion Malleable Iron Co., Mich
Alloy Precision Castings Co., Ohio
Almont Mfg. Co., Mich
Alten Foundry & Machine Works, Inc., Ohio
American Brake Shoe Co., NY
American Cast Iron Pipe Co., Ala
American Foundries Co., Mich
Apex Foundry, Inc., Mich
Apex Steel Corp., Ltd., Calif
Arzt, T.L. Foundry Co., Ill
Atlantic Foundry Co., Ohio
Banner Iron Works, Mo
Barber Iron Work, Inc., La
Bay City Foundry Co., Mich
Beaver Valley Alloy Foundry Co., Pa
Belle City Malleable Iron, Racine Steel Castings Co., Wis
Beloit Foundry Co., Ill
Bethlehem Steel Co., Pa
Bierman-Everett Foundry Co., NJ
Bignall Co., NY
Bonnot Co., Ohio
Brillion Iron Works, Inc., Wis
Brom Machine & Foundry Co., Minn
Butler Engine & Foundry Co., Inc., Pa
Cadillac Malleable Iron Co., Mich
Calumet Div., Calumet & Hecla, Inc., Mich
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Casting Service Corp. of Michigan, Mich
Chambersburg Engineering Co., Pa
Chemung Foundry Corp., NY
Chicago Hardware Foundry Co., Ill
Cleveland Foundry & Mfg. Co., Inc., Tenn
Crawford & Doherty Foundry Co., Ore
Curtiss-Wright Corp., NY
Dalton Foundries, Inc., Ind
Darling Valve & Mfg. Co., Pa
Dayton Foundry, Calif
Deuscher, H.P. Co., Ohio
Duriron Co., Inc., Ohio
Ehrsam, J.B. & Sons Mfg. Co., Kan
Electron Corp., Colo
Elk Engineering Works, Inc., Pa
Elkhart Iron Works, Mich
Engineered Castings Div., American Brake Shoe Co., NY
Enterprise Wheel & Car Corp., Va
Erie Casting Co., Pa
Esco Corp., Ore
Florence Pipe Foundry & Machine Co., NJ
Flynn & Emrich Co., Md
Forest City Foundries Co., Ohio
Frederick Iron & Steel, Inc., Md
Fremont Casting Co., Mass
G. & C. Foundry Co., Ohio
Gale Mfg. Co., Mich
General Electric Co., Foundry Dept., NY
Gillett & Eaton, Inc., Minn
Goslin Birmingham Mfg. Co., Inc., Ala
Grafton Foundry Co., Wis
Grede Foundries, Inc., Wis
Green Bay Foundry & Machine Works, Wis
Greenlee Foundry Co., Ill
Grimm Foundry Co., Inc., NJ
Gunite Foundries Corp., Ill
H & H Foundry Machine Co., Pa
Hamilton Foundry, Inc., Ohio
Hansell-Elcock, Ill
Helmick Foundry-Machine Co., W.Va
Hewitt, John Foundry Co., NJ
Howard Foundry Co., Ill
Irwin-Sensenich Corp., Pa
Janney Cylinder Co., Pa
Kanawha Mfg. Co., W.Va
Keen Foundry Co., Inc., Ind
Kingsport Foundry & Mfg. Corp., Tenn
Kolcast Industries Div., Thompson Products, Inc., Ohio
Kramer Bros. Foundry Co., Ohio
Kutztown Foundry & Machine Corp., Pa
Kwikset Powdered Metal Products, Calif
Lake Erie Foundry Co., NY
Lang-Scharmann & Co., Wis
Lawton, C.A. Co., Wis
Liberty Foundry Co., Mo
Lincoln Foundry Corp., Calif
Link-Belt Co., Ill
Littlestown Hardware & Foundry Co., Inc., Pa
Lodi Iron Works, Inc., Calif
Long Beach Iron Works, Calif
Macaulay, H.C. Foundry Co., Calif
Manufacturers Iron Foundry, Inc., Conn
McLanahan & Stone Corp., Pa
Meehanite Metal Corp., NY —Ad p 431
Metropolitan Iron Foundry, NY
Midwestern Foundries, Inc., Ind
Montague Machine Co., Mass
National Malleable & Steel Castings Co., Ohio
Neenah Foundry Co., Wis
Oak Hill Foundry & Machine Works, Ohio
Oakland Foundry & Machine Co., Mich
Oil City Iron Works, Tex
Overmyer Mould Co., Inc., Ind
Parker-Street Castings Co., Ohio
Perfect Circle Corp., Ind
Perkins, Henry Co., Mass
Pittsburgh Foundry & Machine Co., Pa
Pohlman Foundry Co., Inc., NY
Posey Iron Works, Inc., Pa
Potts, C. & G. & Co., Ind
Prescott Co., Mich
Pusey & Jones Corp., Del
Quaker Alloy Casting Co., Pa
Republic Steel Corp., Ohio
Richmond Foundry & Mfg. Co., Inc., Va
Ridge Foundry, Calif
Riverside Foundry & Galvanizing Co., Mich
Rosedale Foundry & Machine Co., Pa
Ross-Meehan Foundries, Tenn
St. Marys Foundry Co., Ohio
Schaefer-Goodnow Foundries, Inc., Pa
Schneider, Bowman Co., Inc., Pa
Scudder, E.J. Foundry & Machine Co., NJ
Shakopee Foundry Co., Minn
Shartle Div., Black-Clawson Co., Ohio
Sheffield Foundry Co., Ill
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio
Sibley Machine & Foundry Corp., Ind
Sioux City Foundry & Boiler Co., Iowa
Sonith Foundries Div., Food Machinery & Chemical Corp., Ind
Sorbo-Mat Process Engineers, Mo
Sparta Foundry Div., Muskegon Piston Ring Co., Mich
Springfield Foundry Co., Mass
Spuck Iron & Foundry Co., Mo
Star Heel Plate Co., Inc., NJ
Stuart Foundry Co., Mich
Superior Foundry, Inc., Ohio
Taylor & Co., Inc., NY
Taylor & Boggis Foundry, Ohio
Taylor-Wharton Co., Div. of Harsco Corp., NJ
Texas Foundries, Inc., Tex
Tower Grove Foundry, Mo
Union Iron Works, Wash
United Shoe Machinery Corp., Mass
U.S. Pipe & Foundry Co., Ala
Uniworld Research Corp. of America, Ohio
Valley Iron Works, Minn
Viking Pump Co., Iowa
Wall Colmonoy Corp., Mich
Washington Iron Works, Wash
Waterman Industries, Inc., Calif
West Point Foundry & Machine Co., Div. of Batson-Cook Co., Ga
Zenith Foundry Co., Wis

Iron, Gray

(castings)

ACF Industries, Inc., NY
Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Acme Foundry & Machine Co., Kan
Acme Foundry & Machine Co., Okla
Advance Foundry Co., Ohio
Albert Lea Foundry-Queen Products Div., King-Seeley Thermos Co., Minn
Allegheny Foundry Co., Pa
Allis-Chalmers Mfg. Co., Wis
Alloy Precision Castings Co., Ohio
Almont Mfg. Co., Mich
Alten Foundry & Machine Works, Inc., Ohio
American Brake Shoe Co., NY
American Cast Iron Pipe Co., Ala
American Foundries Co., Mich
American Foundry Co., Inc., Ind
American Laundry Machinery Co., NY
Apex Foundry, Inc., Mich
Apex Steel Corp., Ltd., Calif
Appleton Electric Co., Ill
Arneson Foundry Co., Wis
Arzt, T.L. Foundry Co., Ill
Atlantic Foundry Co., Ohio
Atlas Foundry Co., Ohio
Atlas Foundry & Mfg. Co., Calif
Auburn Foundry, Inc., Ind
Avco Mfg. Corp., New Idea Div., NY
Banner Iron Works, Mo
Barber Iron Works Inc., La
Barnett Foundry & Machine Co., NJ
Bay City Foundry Co., Mich
Becker, L.A. Foundry Co., Mo
Bellaire Stove Co., Ohio
Belle City Malleable Iron, Racine Steel Castings Co., Wis
Beloit Foundry Co., Ill
Bethlehem Steel Co., Pa
Bierman-Everett Foundry Co., NJ
Bignall Co., NY
Black-Clawson Co., Ohio
Bond, Charles Co., Pa
Bonnot Co., Ohio
Brake Shoe & Castings Div., American Brake Shoe Co., NY
Brillion Iron Works, Inc., Wis
Bruce Foundry and Mfg. Co., Mich
Butler Engine & Foundry Co., Inc., Pa
Calumet Div., Calumet & Hecla, Inc., Mich
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Casting Service Corp. of Michigan, Mich
Central Specialty Div., King-Seeley Thermos Co., Mich
Chambersburg Engineering Co., Pa.
Chemung Foundry Corp., NY
Chicago Hardware Foundry Co., Ill
Cleveland Foundry & Mfg. Co., Inc., Tenn
Columbiana Pump Co., Ohio
Compton Foundry, Calif
Continental Gin Co., Ala
Cooper-Bessemer Corp., Ohio
Crawford & Doherty Foundry Co., Ore
Dalton Foundries, Inc., Ind
Dana Corp., Auburn Div., Ind
Darling Valve & Mfg. Co., Pa
Dayton Malleable Iron Co., Ohio
Decatur Casting Co., Ind
De Laval Steam Turbine Co., NJ
Detroit Brass & Malleable Co., Mich
Deuscher, H.P. Co., Ohio
Dexter Foundry Div., Philco Corp., Iowa
Dodge Mfg. Co., Ind

Dostal Foundry & Machine Co., Mich
Eaton Mfg. Co., Foundry Div., Mich.
—Ad p 405
Ehrsam, J.B. & Sons Mfg. Co., Kan
Electron Corp., Colo
Elk Engineering Works, Inc., Pa
Elkhart Foundry & Machine Co., Inc., Ind
Elkhart Iron Works, Mich
Empire Pattern and Foundry Co., Okla
Engineered Castings Div., American Brake Shoe Co., NY
Enterprise Wheel & Car Corp., Va
Erie Casting Co., Pa
Fearon Foundry Co., Ill
Florence Pipe Foundry & Machine Co., NJ
Florin Foundry & Mfg. Co., Pa
Flynn & Emrich Co., Md
Forest City Foundries Co., Ohio
Frederick Iron & Steel, Inc., Md
Fremont Casting Co., Mass
Fulton Foundry & Machine Co., Inc., Ohio
G. & C. Foundry Co., Ohio
Gale Mfg. Co., Mich
Gartland-Haswell Foundry, Inc., Ohio
General Electric Co., Foundry Dept., NY
General Foundry & Mfg. Co., Mich
General Iron Works Co., Colo
General Motors Corp., Central Foundry Div., Mich
Georgia Iron Works, Ga
Gillett & Eaton, Inc., Minn
Glamorgan Pipe & Foundry Co., Va
Goslin-Birmingham Mfg. Co., Inc., Ala
Gowanda Furnaces, Inc., NY
Grafton Foundry Co., Wis
Grede Foundries, Inc., Wis
Green Bay Foundry & Machine Works, Wis
Greenlee Foundry Co., Ill
Grimm Foundry Co., Inc., NJ
Gunite Foundries Corp., Ill
H & H Foundry Machine Co., Pa
Hamilton Foundry, Inc., Ohio
Hansell-Elcock, Ill
Hardinge Mfg. Co., Pa
Headford Bros. & Hitchins Foundry Co., Iowa
Helmick Foundry-Machine Co., W.Va
Hewitt, John Foundry Co., NJ
Hodgson Foundry Co., Ill
Howard Foundry Co., Ill
Independence Stove & Mfg. Co., Mo
Industrial & Furnace Car Div., Irwin-Sensenich Corp., Pa
International Harvester Co., Ill
Johnstone Foundries, Inc., Pa
Kanawha Mfg. Co., W.Va
Kansas City Hay Press Co., Mo
Katelman Foundry & Mfg. Co., Iowa
Keen Foundry Co., Inc., Ind
Kelly Foundry Co., Pa
Kingsport Foundry & Mfg. Corp., Tenn
Koehring Co., Wis
Kramer Bros. Foundry Co., Ohio
Kutztown Foundry & Machine Corp., Pa
Lake Erie Foundry Co., NY
Lakeside Malleable Casting Co., Wis
Lang-Scharmann & Co., Wis
Lawton, C.A. Co., Wis
Le Baron, E.L. Foundry, Mass
Lehigh, Inc., Pa
Letakas Foundry Inc., Ind
Lewistown Foundry & Machine Co., Pa
Liberty Foundry Co., Mo
Lincoln Foundry Corp., Calif
Lincoln Iron Works, Vt
Link-Belt Co., Ind
Littite Foundries, Inc., Mich
Littlestown Hardware & Foundry Co., Inc., Pa
Lodge Mfg. Co., Tenn
Lodi Iron Works, Inc., Calif
Long Beach Iron Works, Calif
Macaulay, H.C. Foundry Co., Calif
Madison Foundry Co., Ohio
Manufacturers Iron Foundry, Inc., Conn
McCarter Iron Works, Inc., Pa
McLanahan & Stone Corp., Pa
Meehanite Metal Corp., NY
—Ad p 431
Metropolitan Iron Foundry, NY
Midwestern Foundries, Inc., Ind
Milwaukee Malleable & Grey Iron Works, Wis
Montague Machine Co., Mass
Morrisville Foundry Co., Inc., Vt
National Grey Iron Foundry, Ill
National Malleable & Steel Castings Co., Ohio
National Supply Co., Pa
Neenah Foundry Co., Wis
Noble & Wood Machine Co., NY
Oak Hill Foundry & Machine Works, Ohio
Oakland Foundry & Machine Co., Mich
Oil City Iron Works, Tex
Overmyer Mould Co., Inc., Ind
Palmyra Foundry Co., Inc., NJ
Parker-Street Castings Co., Ohio
Peoria Malleable Casting Co., Ill
Pequonnock Foundry, Inc., Conn
Perfect Circle Corp., Ind
Perkins, Henry Co., Mass
Pittsburgh Foundry & Machine Co., Pa
Pohlman Foundry Co., Inc., NY
Posey Iron Works, Inc., Pa
Potts, C. & G. & Co., Ind
Prescott Co., Mich
Pusey & Jones Corp., Del
Refinery Castings Co., Tex
Republic Steel Corp., Ohio
Richmond Foundry & Mfg. Co., Inc., Va
Ridge Foundry, Calif
Riverside Foundry Co., Pa
Riverside Foundry & Galvanizing Co., Mich
Rockwell Engineering Co., Ill
Rodney Hunt Machine Co., Mass
Rosedale Foundry & Machine Co., Pa
Ross-Meehan Foundries, Tenn
St. Marys Foundry Co., Ohio
San Francisco Iron Foundry, Calif
Savannah Machine & Foundry Co., Foundry Div., Ga
Schaefer-Goodnow Foundries, Inc., Pa
Schneider, Bowman Co., Inc., Pa
Scudder, E.J. Foundry & Machine Co., NJ
Selma Foundry & Machine Co., Ala
Shakopee Foundry Co., Minn
Shartle Div., Black-Clawson Co., Ohio
Sheffield Foundry Co., Ill
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio
Sibley Machine & Foundry Corp., Ind
Sioux City Foundry & Boiler Co., Iowa
Somerset Foundry & Machine Co., Pa
Sonith Foundries Div., Food Machinery & Chemical Corp., Ind
Sorbo-Mat Process Engineers, Mo
Southern Car & Mfg. Co., Inc., Ala
Sparta Foundry Div., Muskegon Piston Ring Co., Mich
Spencer's, I.S. Sons, Inc., Conn
Spring City Foundry Co., Pa
Springer's Foundry Co., Inc., Ind
Springfield Foundry Co., Mass
Spuck Iron & Foundry Co., Mo
Star Heel Plate Co., Inc., NJ
Stearns-Roger Mfg. Co., Colo
Sterling Foundry Co., Ill
Sterrit-Thomas Foundry Co., Pa
Stuart Foundry Co., Mich
Superior Foundry, Inc., Ohio
Swayne-Robinson & Co., Ind
Swett, A.L. Iron Works, NY
Taylor & Co., Inc., NY
Taylor & Boggis Foundry, Ohio
Terre Haute Malleable & Mfg. Corp., Ind
Texas Foundries, Inc., Tex
Tower Grove Foundry, Mo
Union Iron Works, Wash
United Shoe Machinery Corp., Mass
U.S. Pipe & Foundry Co., Ala
Utica General Jobbing Foundry, Inc., NY
Valley Iron Works, Minn
Viking Pump Co., Iowa
Vulcan Foundry Co., Calif
Vulcan Rail & Construction Co., NY
Washington Iron Works, Wash
Waterman Industries, Inc., Calif
Webster Mfg., Inc., Ohio
Werner Foundry & Machine Co., Pa
West Point Foundry & Machine Co., Div. of Batson-Cook Co., Ga
Western Foundry & Machine Works, Inc., Kan
Western Iron & Foundry Co., Inc., Kan
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
Wheland Co., Tenn
Wollaston Foundry Corp., Mass
Woodruff & Edwards, Inc., Ill
Yale & Towne Mfg. Co., Ill
Zellner Foundry Co., Ohio
Zenith Foundry Co., Wis

Iron, Ingot

Alten Foundry & Machine Works, Inc., Ohio (o)
Armco Steel Corp., Ohio (o,q,z,bb,cc,dd)
Cannon-Muskegon Corp., Mich (w)
Foote Mineral Co., Pa (aa)
Hayden Wire Works, Inc., Mass (o,bb,ee,ff)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
National Moldite Co., NY (aa)
National-U.S. Radiator Corp., Plastic Metals Div., NY (aa)
Nesor Alloy Products Co., NJ (ff)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (ff)
Phoenix Steel Corp., NY
Rathbone Corp., Mass (o,bb)
Republic Steel Corp., Ohio (w,aa)
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio (o,ee)
Star Heel Plate Co., Inc., NJ (bb)
Superior Tube Co., Pa (ee)
Sylvania Electric Products, Inc., Parts Div., Pa (ff)
Tube Methods Inc., Pa (ee)

Iron, Malleable

(castings)

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Acme Steel & Malleable Iron Works, NY
Albion Malleable Iron Co., Mich
Alloy Precision Castings Co., Ohio
American Chain & Cable Co., Pa
American Malleable Castings Co., Ohio
American Steel and Wire Div., U.S. Steel Corp., Ohio
Appleton Electric Co., Ill
Auto Specialties Mfg. Co., Mich
Badger Malleable & Mfg. Co., Wis
Belle City Malleable Iron, Racine Steel Castings Co., Wis
Cadillac Malleable Iron Co., Mich
Canton Malleable Iron Co., Ohio
Chicago Malleable Castings Co., Ill
Connecticut Malleable Castings Co., Conn
Dana Corp., Auburn Div., Ind
Dayton Malleable Iron Co., Ohio
Detroit Brass & Malleable Co., Mich
Eastern Malleable Iron Co., Del
General Electric Co., Foundry Dept., NY
General Motors Corp., Central Foundry Div., Mich
Hodgson Foundry Co., Ill
Iowa Malleable Iron Co., Iowa
Ironton Malleable Div., Dayton Malleable Iron Co., Ohio
Jamestown Malleable Iron Corp., NY
Laconia Malleable Iron Co., NH
Lake City Malleable Co., Ohio
Lakeside Malleable Castings Co., Wis
Lancaster Malleable Castings Co., Pa
Lehigh, Inc., Pa
Lincoln Foundry Corp., Calif
Link-Belt Co., Ind
McCarter Iron Works, Inc., Pa
Meadville Malleable Iron Co., Pa
Meeker Foundry Co., NJ
Metropolitan Iron Foundry, NY
Milwaukee Malleable & Grey Iron Works, Wis
Moline Iron Works, Ill
Muncie Malleable Foundry Co., Ind
National Malleable & Steel Castings Co., Ohio
Northern Malleable Iron Co., Minn
Pennsylvania Malleable Iron Corp., Pa
Peoria Malleable Casting Co., Ill
Prescott Co., Mich
Rockwell Engineering Co., Ill
St. Louis Malleable Castings Co., Mo
Sorbo-Mat Process Engineers, Mo
Star Heel Plate Co., Inc., NJ
Superior Steel & Malleable Castings Co., Mich
Terre Haute Malleable & Mfg. Corp., Ind
Texas Foundries Inc., Tex
United Shoe Machinery Corp., Mass
U.S. Challenge & Challenge Co., Ill
Vulcan Rail & Construction Co., NY
Webster Mfg., Inc., Ohio
West Virginia Malleable Iron Co., W.Va
Westmoreland Malleable Iron Co., NY

Iron, Malleable Pearlitic

(castings)

Albion Malleable Iron Co., Mich
American Malleable Castings Co., Ohio

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Auto Specialties Mfg. Co., Mich
Badger Malleable & Mfg. Co., Wis
Belle City Malleable Iron Co., Wis
Cadillac Malleable Iron Co., Mich
Canton Malleable Iron Co., Ohio
Chain Belt Co., Wis
Crane Co., Metals Div., Pa
Dalton Foundries, Inc., Ind
Dayton Malleable Iron Co., G.H.R. Div., Ohio
Eastern Malleable Iron Co., Del
Erie Malleable Iron Co., Pa
Federal Malleable Co., Wis
General Electric Co., Foundry Dept., NY
I-F Mfg. Co., Ohio
Ironton Malleable Div., Dayton Malleable Iron Co., Ohio
Jamestown Malleable Iron Corp., NY
Laconia Malleable Iron Co., NH
Lakeside Malleable Casting Co., Wis
Lehigh Foundries Co., Div. of Lehigh Inc., Pa
Link-Belt Co., Ill
Meadville Malleable Iron Co., Pa
Milwaukee Malleable & Grey Iron Works, Wis
Moline Malleable Iron Co., Ill
National Malleable & Steel Castings Co., Ohio
Northern Malleable Iron Co., Minn
Peoria Malleable Casting Co., Ill
St. Louis Malleable Casting Co., Mo
Star Heel Plate Co., Inc., NJ
Texas Foundries, Inc., Tex
Wagner Malleable Iron Co., Ill
Webster Mfg., Inc., Ohio

Iron, Nodular or Ductile

(castings)

Acme Foundry & Machine Co., Okla
Adirondack Steel Casting Co., NY
Advance Foundry Co., Ohio
Alloy Precision Castings Co., Ohio
Alten Foundry & Machine Works Inc., Ohio
American Brake Shoe Co., NY
American Cast Iron Pipe Co., Ala
Apex Foundry, Inc., Mich
Artz, T. L. Foundry Co., Ill
Atlantic Foundry Co., Ohio
Bay City Foundry Co., Mich
Beloit Foundry Co., Ill
Bethlehem Steel Co., Pa
Black-Clawson Co., Ohio
Bonnot Co., Ohio
Brillion Iron Works, Inc., Wis
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Chambersburg Engineering Co., Pa
Chicago Hardware Foundry Co., Ill
Crawford & Doherty Foundry Co., Ore
Curtiss-Wright Corp., Metals Processing Div., NY
Dayton Foundry, Calif
Deuscher, H.P. Co., Ohio
Dodge Steel Co., Pa
Ductile Iron Foundry, Inc., Conn
Electron Corp., Colo
Engineered Castings Div., American Brake Shoe Co., NY
Erie Casting Co., Pa
General Electric Co., Foundry Dept., NY
Goslin Birmingham Mfg. Co., Inc., Ala
Grede Foundries, Inc., Wis
Gunite Foundries Corp., Ill
Hamilton Foundry Inc., Ohio
Hansell-Elcock, Ill
Hodgson Foundry Co., Ill
Howard Foundry Co., Ill
Jamestown Malleable Iron Corp., NY
Janney Cylinder Co., Pa
Kanawha Mfg. Co., W.Va
Kutztown Foundry & Machine Corp., Pa
Lincoln Foundry Corp., Calif
Macauley, H.C. Foundry Co., Calif
Meehanite Metal Corp., NY
—Ad p 431
Montague Machine Co., Mass
Neenah Foundry Co., Wis
Oil City Iron Works, Tex
Perfect Circle Corp., Ind
Perkins, Henry Co., Mass
Pohlman Foundry Co., Inc., NY
Pratt, William E. Foundry Div., Joslyn Mfg. & Supply Co., Ill
Rosedale Foundry & Machine Co., Pa
Ross-Meehan Foundries, Tenn
Sandy Hill Iron & Brass Works, NY
Savannah Machine & Foundry Co., Foundry Div., Ga
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio
Sioux City Foundry & Boiler Co., Iowa
Southern Car & Mfg. Co., Inc., Ala
Star Heel Plate Co., Inc., NJ
Stuart Foundry Co., Mich
Taylor-Wharton Co., Div. of Harsco Corp., NJ
Texas Foundries, Inc., Tex
United Shoe Machinery Corp., Mass
Viking Pump Co., Iowa

Iron, Powders

Alan Wood Steel Co., Pa
Alloy Metal Powders, Inc., Iowa
Antara Chemicals, Div. of General Aniline & Film Corp., NY
Belmont Smelting & Refining Works, Inc., NY
Crane Co., Metals Div., Pa
Easton Metal Powder Co., Div. of American Mannex Corp., Pa
—Ad p 418
Ekstrand & Tholand, NY
Foote Mineral Co., Pa
Glidden Co., Chemical Divs., Metals Dept., Ind
Metals Dept., Pa
Globe Steel Abrasive Co., Ohio
Hardy, Charles, Inc., NY
Hoeganaes Sponge Iron Corp., NJ
—Ad p 428
Johnson, A. & Co., Inc., NY
Kwikset Powdered Metal Products, Calif
Linde Co. Div., Union Carbide Corp., NY
Magnetic Powders, Inc., Pa
National Moldite Co., NJ
National-U.S. Radiator Corp., Plastic Metals Div., NY
Norwalk Powdered Metals, Inc., Conn
Pyron Corp., NY
—Ad p 430
Shakopee Foundry Co., Minn
Sorbo-Mat Process Engineers, Mo
Steel Shot Producers, Inc., Pa
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
Uniworld Research Corp. of America, Ohio

Iron, Wrought

Albert Pipe Supply Co., Inc., NY (ee)
American Silver Co., NY (v,dd)
Byers, A.M., Pa (o,q,z,ee)
Dormont Mfg. Co., Pa (ee)
Gary Steel Products Corp., Va (o,z,bb)
Lockhart Iron & Steel Co., Pa (o, q,bb,dd)
National Electric Div., H.K. Porter Co., Pa (ee)
Rathbone Corp., Mass (o,bb)
Shaw-Kendall Engineering Co., Ohio (ee)
Vulcan Rail & Construction Co., NY (o,dd,ee)

Isocyanates

(see Urethanes)

Isoprene - Isobutylene Rubber

Adhesive Products Corp., NY (x)
Armstrong Cork Co., Pa (bb,cc,dd)
Atlas Mineral Products Co., Pa (cc)
Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Bond International, Inc., Mich (y,ee)
Brown Rubber Co., Inc., Ind (u)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Ill (p)
Colonial Rubber Co., Ohio
(y,cc)—Ad p 416
Continental Rubber Works, Pa (bb,cc, dd,ee)
Dayton Rubber Co., Ohio (y,bb,cc,dd, ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Enjay Chemical Co. Div., Humble Oil & Refining Co., NY
(p)—Ad pp 218-219
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (y,cc,ee)
Garlock Packing Co., NY (y,cc)
Geauga Industries Co., Ohio (y,bb,dd)
Goshen Rubber Co., Inc., Ind (y)
Hewitt-Robins, Inc., Conn (cc,ee)
Maloney, F.H. Co., Tex (y)
Martin Rubber Co., Inc., NJ (y,dd,ee)
Mid-States Rubber Products, Inc., Ind (y)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (x)
Paeco Rubber Co., Inc., Ohio (y,dd,ee)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (y)
Parker, Stearns & Co., Inc., NY (y, bb,cc,dd,ee)
Pawling Rubber Corp., NY (bb,dd,ee)
Polymer Chemical Co., Ohio (x)
Rand Rubber Co., NY (t,cc)
Raybestos-Manhattan, Inc., Plastic Products Div., Pa (x)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p,y,ee)
Roberts Toledo Rubber Co., Ohio (ee)
Rogers Corp., Conn (cc,dd)
Roth Rubber Co., Ill (y,cc)
Sheller Mfg. Corp., Mich (u)
Sperry Rubber & Plastics Co., Ind (dd,ee)
Standard Products Co., Mich (y)
Stockwell Rubber Co., Inc., Pa (y, cc,dd)
Technical Specialties Co., NY (dd)
Trostel, Albert Packing, Ltd., Wis (y)
U.S. Rubber Co., Kem-Blo Dept., Conn (u)
Vulcan Div., Reeves Bros. Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Lacquers

(see Organic Coatings)

Laminates

(see below; also Pre-Impregnated Materials)

Laminates, High Pressure, Plastics or Rubber

(sheet, rod or tube; incl. clad laminates)

Acme Specialties, Inc., Pa (k,l,m)
Allied Resinous Products, Inc., Ohio (k)
American Agile Corp., Ohio (k)
American Brakeblok Div., American Brake Shoe Co., Mich (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l)
American Polyglas Corp., NJ (l)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Auburn Plastic Engineering, Ill (k)
Baer, N.S. Co., NJ (l)
Bolta Products Div., General Tire & Rubber Co., Mass (k)
Brinkerhoff Brass & Bronze Works, Inc., NY (l)
Cadillac Plastic & Chemical Co., Mich (l)
Calfibe Co., Inc., Calif (l)
Caradco Corp., Durel Div., Iowa (l)
Castle Rubber Co., Pa (m)
Coating Products, Inc., NJ (l)
Colonial Art Co., Inc., Mass (k)
Connecticut Hard Rubber Co., Conn (m)
Conolite Div., Continental Can Co., Del (l)
Consoweld Corp., Wis (l)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
Corbell, Inc., NY (l)
Davidson Rubber Co., Mass (m)
Davis, Joseph Plastics Co., NJ (k)
Delta Plastics Co., NJ (l)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (m)
Dumont Corp., Ill (l)
Durel, Inc., Iowa (l)
Everlite Corp., Wash (l)
Fabricon Products Div., Eagle-Picher Co., Mich (l)
Formica Corp., Sub. of American Cyanamid Co., Ohio (l)
Gatke Corp., Ill (l)
General Electric Co., Laminated Products Dept., Ohio
(l)—Ad p 369
General Plastics Corp., NJ (k,l)
General Tire & Rubber Co., Ind (l)
H & R Plastics Industries, Inc., Pa (k)
Halogen Insulator & Seal Corp., Ill (l)
Hartwell, H.N. & Son, Inc., Mass (k)
Haskelite Mfg. Div., Evans Products Co., Mich (l)
Haveg Industries, Inc., Del (l)
Home Rubber Co., NJ (m)
Insulation Mfrs. Corp., Ill (k)
Iten Fibre Co., Ohio (l)
Johns-Manville Corp., NY (k,l)
Kaykor Industries, Inc., Div. of Kaye-Tex Mfg. Corp., NJ (k)
Kerrco, Neb (k,l)
Lewis, J.P. Co., Plastic Products Div., NY (l)
Luminous Resins, Inc., Ill (k)
Maloney, F.H. Co., Tex (l)
Marblette Corp., NY (l)
Mechanical Rubber Products Co., NY (l)
Mica Corp., Calif (l)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (l)
Micarta Div., Westinghouse Electric Corp., SC
(l)—Ad pp 239-246
Moxness Products, Inc., Wis (l,m)
National Vulcanized Fibre Co., Del (l)
New England Laminates Co., Inc., Conn (l)
Northern Plastics Corp., Wis (l)
Panelyte Div., St. Regis Paper Co., NJ (l)
Penn Fibre & Specialty Co., Inc., Pa (l)
Permali, Inc., Pa (l)
Philrus Products Co., NJ (k,l)
Porter, William Co., Calif (l)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Replac Corp., Ohio (k,l,m)
Richardson Co., NY (l)
Reflin Co., Calif (l)
Rogers Corp., Conn (l)
Ryerson, Joseph T. & Son, Inc., Ill (l)
Seiberling Rubber Co., Plastics Div., Ohio (k,m)
Shamban, W.S. & Co., Ind (k)
Sierracin Corp., Calif (k,l)
Sillcocks Miller Co., NJ (k)
Spaulding Fibre Co., Inc., NY
(l)—Ad p 277
Standard Insulation Co., NJ (l)
Sun Steel Co., Ill (k)
Swedlow, Inc., Calif (k,l)
Synthane Corp., Pa (l)
Taylor Fibre Co., Pa
(l)—Ad p 265
Thermoid Div., H.K. Porter Co., Pa (k,m)
Thombert, Inc., Iowa (l)
U. S. Gasket Plastics Div., Garlock Packing Co., NJ (k)

Vulcan Div., Reeves Bros. Inc., NY (m)
Vulcanized Rubber & Plastics Co., Pa (m)
Warren Plastics & Engineering, Inc., Mich (l)
Westlake Plastics Co., Pa (l)

Laminates, Low Pressure, Plastics or Rubber

(sheet, rod or tube; incl. clad laminates)

Acme Specialties, Inc., Pa (k,l,m)
Aerojet-General Corp., Structural Materials Div., Calif (l)
Allegheny Plastics, Inc., Pa (k)
Allied Resinous Products, Inc., Ohio (k)
Alsynite Div., Reichhold Chemicals, Inc., Calif
American Agile Corp., Ohio (k)
American Brake Shoe Co., NY (k)
American Insulator Corp., Pa
(l)—Ad p 433
American Polyglas Corp., NJ (l)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (m)
Argo Plastic Products Co., Ohio (l)
Artmor Plastics Corp., Md (l)
Auburn Plastic Engineering, Ill (l)
Baer, N.S. Co., NJ (l)
Biggs, Carl H. Co., Inc., Calif (l)
Blank, Arthur & Co., Inc., Mass (k)
Brinkerhoff Brass & Bronze Works, Inc., NY (l)
Cadillac Plastic & Chemical Co., Mich (k,l)
Calfibe Co., Inc., Calif (l)
Carroll, J.B. Co., Ill (k)
Castle Rubber Co., Pa (m)
Cincinnati Industries, Inc., Ohio (k)
Coating Products, Inc., NJ (l)
Connecticut Hard Rubber Co., Conn (m)
Consolidated Molded Products Corp., Pa (l)
Continental Can Co., NY (l)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
Corite Products Inc., Ill (l)
Corrulux Div., L.O.F. Glass Fibers Co., Tex (l)
Delta Plastics Co., NJ (l)
Dumont Corp., Calif
(l)
Dura Plastics of New York, Inc., NY (k)
Eljay Corp., Md (k,l)
Emerson & Cuming, Inc., Mass (k,l,m)
Everlite Corp., Wash (l)
Fiber Glass Industries, Inc., NY (l)
Fiberglass Ohio Inc., Ohio (l)
Filon Plastics Corp., Calif (l)
Foss Mfg. Co., Id (l)
Frost Rubber Co., Ill (m)
Fry Plastics International, Calif (k)
General Plastics Corp., Ind (k)
General Plastics Corp., NJ (k,l)
Gering Plastics, Div. of Studebaker-Packard Corp., NJ (k)
Glastic Corp., Ohio (l)
Haskelite Mfg. Div., Evans Products Co., Mich (l)
Haveg Industries, Inc., Del (l)
Hays Mfg. Co., Pa (l)
Heil Process Equipment Corp., Ohio (l)
Home Rubber Co., NJ (m)
Insulation Mfrs. Corp., Ill (k)
Kaykor Industries, Inc., NJ (k)
Kerrco, Neb (k,l)
Kevinite Div., Swedlow, Inc., Ohio (l)
Koch, H. & Sons, Calif (l)
Laminated Plas-Tex Corp., Ohio (k)
Lamtex Industries, Inc., NY (l)
Lewis, G.B. Co., Wis
(l)—Ad p 434
Lun Laminates, Inc., NY (l)
Mechanical Rubber Products Co., NY (l)
Mica Corp., Calif (l)
Mica Insulator Co., NY (l)
Micarta Div., Westinghouse Electric Corp., SC (l)
Minnesota Mining & Mfg. Co., Missile Industry Liaison, Minn
(l)—Ad p 367
Minnesota Mining & Mfg. Co., Reinforced Plastics Div., Minn (l)
National Vulcanized Fibre Co., Del (l)
New England Laminates Co., Inc., Conn (l)
Olympic Plastics Co., Inc., Calif (l)
Penn Fibre & Specialty Co., Inc., Pa (l)
Permali, Inc., Pa (l)
Perry Plastics Inc., Pa (k,l)
Polygon Plastic Co., Ind (l)
Porter, William Co., Calif (l)
Precision Paper Tube Co., Ill (l)
Rand Rubber Co., NY (k,l)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Reflin Co., Calif (l)
Replac Corp., Ohio (l,m)
Resolite Corp., Pa (l)
Riverside Plastics Corp., NY (l)
Rowland Products, Inc., Conn (k)
Rubber Corp. of America, NY (k)
Russell Reinforced Plastics Corp., NY (l)
Scheri Process Div., Ferro-Co Corp., NY (l)
Sealview Plastics, Inc., Pa (l)
Sewell Mfg. Co., Mich (k)
Shamban, W.S. & Co., Ind (k)
Sierra Electric Corp., Calif (l)
Sierracin Corp., Calif (k,m)
Sillcocks Miller Co., NJ (k)
Simoniz Products Div., Simoniz Co., Ill (k)
Southern Plastics Co., SC (k)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Standard Insulation Co., NJ (l)
Stockwell Rubber Co., Inc., Pa (k,m)
Strick Plastics Co., Pa (m,k,l)
Swedlow, Inc., Calif (k,l)
Tanner Engineering Co., Calif (l)
Urrite Plastics Fabricators, Calif (k)
Vulcan Div., Reeves Bros. Inc., NY (m)
Vulcanized Rubber & Plastics Co., Pa (m)
Warren Plastics & Engineering, Inc., Mich (l)
Westlake Plastics Co., Pa (l)
Winner Mfg. Co., Inc., NJ (l)
Woodall Industries, Inc., Mich (k,l)
Youngstown Sheet & Tube Co., Ohio (l)
Zenith Plastics Co., Sub. of Minnesota Mining & Mfg. Co., Calif (l)

Laminates, High or Low Pressure, Plastics or Rubber—Moldings

(incl. clad laminates)

Admiral Corp., Molded Products Div., Ill (l)
Aerojet-General Corp., Structural Materials Div., Calif (l)
Allied Resinous Products, Inc., Ohio (k)
American Agile Corp., Ohio (k)
American Brakeblok Div., American Brake Shoe Co., Mich (k)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Arrowhead Products, Calif (l,m)
Artmor Plastics Corp., Md (l)
Baer, N.S. Co., NJ (l)
Brunswick Corp., Defense Products Div., Mich (l)
Byers, A.M. Co., Pa (k)
Cadillac Plastic & Chemical Co., Mich (k,l)
Calfibe Co., Inc., Calif (l)
Camfield Fiberglass Plastics, Inc., Mich (l)
Carroll, J.B. Co., Ill (k)
Castle Rubber Co., Pa (m)
Colonial Art Co., Inc., Mass (k)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio (k,m)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
Corite Products, Inc., Ill (l)
Curtiss-Wright Corp., Utica Div., Mich (l)
Dumont Corp., Calif (l)
Eljay Corp., Md (l)
Englander Co., Inc., Industrial Products Div., Md (l)
Felsenthal, G. & Sons, Ill (k)
Fiber Glass Industries, Inc., NY (l)
Formica Corp., Sub. of American Cyanamid Co., Ohio (l)
Foss Mfg. Co., Id (l)
Frost Rubber Co., Ill (m)
Fry Plastics International, Calif (l)
Galigher Co., Utah (k)
Gatke Corp., Ill (l)
General American Transportation Corp., Ill (l)
General Electric Co., Plastics Dept., Ill (l)
General Tire & Rubber Co., Ind (k)
Gering Plastics Div., Studebaker-Packard Corp., NJ (k)
Gisholt Plastics, Wis (l)
Glass Reinforced Plastics Corp., Ohio (l)
Glastic Corp., Ohio
(l)—Ad p 256
Greene, Tweed & Co., Pa (k,l,m)
H & R Plastics Industries, Inc., Pa (k)
Haskelite Mfg. Div., Evans Products Co., Mich (l)
Haveg Industries, Inc., Del (l)
Hawley Products Co., Ill (l)
Hays Mfg. Co., Pa (l)
Hewitt-Robins, Inc., Conn (m)
Home Rubber Co., NJ (m)
Industrial Products Div., General Tire & Rubber Co., Ind (k)
Insulation Mfrs. Corp., Ill (k)
Kaykor Industries, Inc., Div. of Kaye-Tex Mfg. Corp., NJ (k)
Kerrco, Neb (k,l)
Knight, Maurice A. Co., Ohio (l)
Lamtex Industries, Inc., NY (l)
Lone Star Plastics Co., Inc., Tex (l)
Lunn Laminates, Inc., NY (k,l)
Maloney, F.H. Co., Tex (l)
Marion Div., General Tire & Rubber Co., Ind (l)
Mechanical Rubber Products Co., NY (l)
Mica Corp., Calif (l)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (l)
Micarta Div., Westinghouse Electric Corp., SC (l)
Minnesota Mining & Mfg. Co., Reinforced Plastics Div., Minn (l)
Molded Fiber Glass Co., Ohio (l)
National Vulcanized Fibre Co., Del (l)
New England Laminates Co., Inc., Conn (l)
Northwest Plastics Industries, Inc., Minn (l)
Olympic Plastics Co., Inc., Calif (l)
Pam-Pro Plastics, Calif (l)
Panelyte Div., St. Regis Paper Co., NJ
(l)—Ad p 410
Penn Fibre & Specialty Co., Inc., Pa (k)
Permali, Inc., Pa
(l)—Ad p 414
Plymouth Industrial Products, Inc., Wis (k)
Porter, William Co., Calif (l)
REF Mfg. Corp., NY (l)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Replac Corp., Ohio (k,l,m)
Resolite Corp., Pa (l)
Richardson Co., Ill (l)
Riverside Plastics Corp., NY (l)
Russell Reinforced Plastics Corp., NY (l)
Shamban, W.S. & Co., Ind (k)
Sierra Electric Corp., Calif (k)
Spaulding Fibre Co., Inc., NY (l)
Standard Insulation Co., NJ (l)
Stockwell Rubber Co., Inc., Pa (k,m)
Strick Plastics Co., Pa (k,l,m)
Structural Fibers, Inc., Ohio (l)
Sun Rubber Co., Ohio (m)
Swedlow, Inc., Calif (k,l)
Synthane Corp., Pa (l)
Taylor Fibre Co., Pa
(l)—Ad p 265
Thermoid Div., H.K. Porter Co., Pa (l)
Thompson, H.I. Fiber Glass Co., Calif (l)
Toledo Industrial Rubber Co., (l)
Vulcan Div., Reeves Bros., Inc., NY (m)
Warren Plastics & Engineering, Inc., Mich (l)
Waterbury Cos., Inc., Conn (l)
Winner Mfg. Co., Inc., NJ (l)
Wittman, Lawrence & Co., NY (k,l)
Woodall Industries, Inc., Mich (k,l)
Zenith Plastics Co., Sub. of Minnesota Mining & Mfg. Co., Calif (l)

Laminates, Metal-Metal

(incl. "bimetals"; key letters refer to base metal)

Aerojet-General Corp., Structural Materials Div., Calif (a,g,h)
Almco Steel Products Corp., Ind (g)
American Cast Iron Pipe Co., Ala (c,g)
American Silver Co., Inc., NY (b,c,f,g)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Baker & Co., Inc., NJ (b,f)
Bridgeport Brass Co., Conn (b,f,g,h)
Brunswick Corp., Defense Products Div., Mich (a)
Chace, W.M. Co., Mich (a,b,c,e,f,g,h,j)
Composite Industrial Metals, Inc., RI (a,b,c,d,e,f,g,h,j)
Eastern Brass & Copper Co., NY (a)
Eastern Smelting & Refining Corp., Mass (b)
Gar Precision Parts, Inc., Conn (b,f)
General Findings & Supply Co., Industrial Div., Mass (b,f)
General Plate Div., Metals & Controls Corp., Mass (a,b,c,e,f,g,h,j)
Haydon Corp., NY (a,g)
Horton-Angell Co., Mass (b,f)
Improved Seamless Wire Co., RI (b, c,f)
Knapp Mills, Inc., NY (b,g)
Laminated Shim Co., Conn (a,b,g)
Leach & Garner Co., Industrial Div., Mass (b,f)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (b,c,f,g)
Nuclear Metals, Inc., Mass (a,b,c,e, f,g,h)
Presswork, Inc., Mich (b,d)
Pyromet Co., Calif (b,c,d,f,g,h)
Revere Copper & Brass, Inc., Foil Div., NY (a)
Rockwell Engineering Co., Ill (a,b,c, g)
Rockwell-Standard Corp., Stamping Div., NY (a,b,f,g)
Standard Metals Corp., Mass (a,b,c,f, g)
Staver Co., Inc., NY (a,b)
Sylvania Electric Products, Inc., NY (b,f)
Wall Colmonoy Corp., Mich
Wilson, H.A. Co., Div. of Engelhard Industries, Inc., NJ (b,f,g)
Wisconsin Gasket & Mfg. Co., Ohio (b,g)

Laminates, Metal-Organic

(key letters refer to base metal)

Aerojet-General Corp., Structural Materials Div., Calif (a,g,h)
AllianceWall Div., AllianceWare, Inc., Ohio (a,g)
American Nickeloid Co., Ill (a,g)
Anaconda Aluminum Co., Sub. of Anaconda Co., Ky (a)
Arvin Industries, Inc., Ind (a,e,g)
Benjamin Electric Mfg. Co., Ill (g)
Coated Coil Corp., NY (a,g)
Cochran Foil Co., Ky (a)
Dumont Corp., Calif (a)
Enamel Products Co., Ohio (a,c)
Enamelstrip Corp., Sub. of National Steel Corp., Pa (a,b,c,f,g,j)
Gomar Mfg. Co., Inc., NJ (a)
Haydon Corp., NY (a,g)
Hood Rubber Co., Div. of B.F. Goodrich Chemical Co., Mass (a,g)
Kaiser Aluminum & Chemical Sales Inc., Ill (a)
Maloney, F.H. Co., Tex (g)
Met-L-Wood Corp., Ill (a,b,d,f,g)
New England Laminates Co., Inc., Conn (g)
Poloron Products, Inc., NY (a,g)
Simoniz Products Div., Simoniz Co., Ill
Sun Steel Co., Ill (a,e,g)
Young, M.M. Div., Litho-Strip Corp., Ill (a,g)

Laminates, Wood-Metal

Brunswick Corp., Defense Products Div., Mich
Doweloc Div., D. B. Frampton & Co., Ohio
Gamble Brothers, Inc., Special Products Div., Ky
Haskelite Mfg. Div., Evans Products Co., Mich
Keller Products, Inc., NH
Laminated Veneers Co., NY
Met-L-Wood Corp., Ill
Technical Ply-Woods Sales, Ill
U.S. Plywood Corp., NY

Laminating Resins

(see specific plastic or rubber)

Lead and Its Alloys

Advance Stamping Co., Mich (dd)
Alpha Metals, Inc., NJ (n,o,v,w,z,aa, bb,cc,dd)
American Metal Climax, Inc., NY (n, o,w,aa,bb)
American Nickel Alloy Mfg. Corp., NY (w)
American Smelting & Refining Co., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Avril, G. A. Co., Ohio (n,cc,ee)
Bar-Ray Products, NY (v,z,cc)
Bearium Metals Corp., NY (w)
Belmont Smelting & Refining Works, Inc., NY (n,o,q,v,w,z,aa,cc,ff)
Bunker Hill Co., Calif (n,o,w,z,bb,cc, dd,ee,ff)
Cerro Sales Corp., Sub. of Cerro Corp., NY (w)—Ad p 154
Chicago Smelting & Refining Corp., Ill (w)
Crown Metal Co., Wis (n,o,q,w,bb,cc, dd,ee,ff)
Designers Metal Corp., Ill (cc)
Dietzel Lead Burning Co., Pa (n,o,z,cc)
Division Lead Co., Ill (n,o,v,w,z,aa, cc,dd,ee,ff)
Dixie Lead Co., Tex (n,o,q,w,aa,cc)
Eagle-Picher Co., Ohio (aa)
Empire Metal Co., NY (n,o,q,v,w,z, bb,cc,dd,ee,ff)
Evans Metal Co., Ga (w,cc,ee)
Federated Metals Div., American Smelting & Refining Co., NY (n,o, w,cc,ee,ff)
Fox Products Co., Pa (n)
Glidden Co., Ind (aa)
Glidden Co., Chemical Divs., Metals Dept., Ind (aa)—Ad p 397
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (ff)
Hayman, Michael & Co., NY (o,w)
Heil Process Equipment Corp., Ohio (n)
Hettleman, K. & Sons, Inc., Md (w)
Hi-Grade Alloy Corp., Ill (n,o,v,w,z, bb,cc,ee,ff)
Indium Corp. of America, NY (v,cc,dd, ff)
Johnston Foil Div., Standard Packaging Corp., Mo (v,cc)
Kassal Export Co., Inc., NJ (v)
Kinkead Industries, Inc., Ill (cc,dd)
Kirk, Morris P. & Son, Calif (n,o,q,w, z,aa,bb,cc,dd)
Lavin, R. & Sons, Inc., Ill (n,w)
McGean Chemical Co., Ohio (n,o,aa, bb,dd)
Metal & Thermit Corp., NJ (n)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metals Disintegrating Co. Div., American-Marietta Co., NJ (aa)
National Lead Co., NY (n,o,q,w,z, aa,bb,cc,dd,ee,ff)
National Lead Construction Co., Inc., Pa (n,o,w,z,cc,ee,ff)
Nesor Alloy Products Co., NJ (ff)
New England Smelting Works, Inc., Mass (o,w)
Oatey, L.R. Co., Ohio (o,w,cc,dd)
Olds Alloy Co., Calif (q,w)
Peerless Alloy Co., Colo (n,o,q,w,z, bb,cc)
Peerless Roll Leaf Co., Div. of Howe Sound Co., NJ (v,dd)
Pittsburgh Smelting & Refining Co., Pa (o,w,cc)
Plasmadyne Corp., Calif (aa)
Presswork, Inc., Mich (o,cc)
Republic Lead Equipment Co., Ohio (n)
Republic Metals Co., Inc., NY (n,o,q, v,w,z,cc,ee,ff)
Revere Copper & Brass, Inc., Foil Div., NY (v)
River Smelting & Refining Co., Ohio (o,w)
Rotometals, Calif (o,w,bb,cc,dd,ee,ff)
St. Joseph Lead Co., NY (w)
Staver Co., Inc., NY (v,cc,dd)
Stevens, Frederic B., Inc., Mich (n)
Texas Instruments, Inc., Metals & Controls Div., Mass (dd)
Udylite Corp., Mich (n)
U.S. Smelting, Refining & Mining Co., NY (w)
U.S. Stoneware Co., Ohio (n)
Waltham Foundry Co., Mass (w)

Leather and Leather Parts

Alexander Bros. Belting Co. Div., L. H. Shingle Co., Mass
Alexander, E.P. & Son, Mass
Auburn Mfg. Co., Conn
Bond, Charles Co., Pa
Charlotte Leather Belting Co., NC
Chicago Rawhide Mfg. Co., Ill
Chicago-Allis Mfg. Corp., Ill
Donovan, F.C., Inc., Mass
Excelsior Leather Washer Mfg. Co., Inc., Ill
Foss Mfg. Co., Id
Garlock Packing Co., NY
General Gasket, Inc., Conn
Glenn, Joseph & Sons, Inc., Pa
Graton & Knight Co. Div., L. H. Shingle Co., Mass
Haffner Bros. Co., Ohio
Hay, James E. Co., Inc., Mass
Houghton, E.F. & Co., Pa
International Packings Corp., NH
Mechanical Leathers, Inc., Pa
Michigan Leather Products Co., Mich
National Gasket & Washer Mfg. Co., Inc., NY
Norwich Leather Co., Conn
Page Belting Co., NH
Penn Fibre & Specialty Co., Inc., Pa
Porter, William Co., Calif
Rhoads, J.E. & Sons, Del
Schachner Leather & Belting Co., Charlotte Leather Belting Co. Div., NC
Shingle Leather Co., NJ
Sillcocks Miller Co., NJ
Southern Belting & Transmission Co., Ga
Standard Washer & Mat, Inc., Conn
Staver Co., Inc., NY
Truche Leather Co., Mass
Walton Gibb Leather Co., Inc., Pa
Warren Belting Co. Div., L. H. Shingle Co., Mass
Winworth Co., Inc., NJ

Lignum Vitae

(see Wood)

Lithium

American Potash & Chemical Corp., Calif (w)
Belmont Smelting & Refining Works, Inc., NY (o,aa)
Foote Mineral Co., Pa (w)
Hardy, Charles, Inc., NY (aa)
Kawecki Chemical Co., NY (w)
Lithium Corp. of America, Inc., Minn (w,bb,ff)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)

Low Pressure Laminates

(see Laminates)

Magnesium and Its Alloys

Alabama Metallurgical Corp., Ala (w)
Aluminum Co. of America, Pa (n,o, bb)
Aluminum & Magnesium, Inc., Ohio (w)
American Silver Co., NY (v,dd)
American Smelting & Refining Co., NY (n,w)
Apex Smelting Co., Ill (n,w)
Arcos Corp., Pa (ff)
Armet Alloys, Inc., Ohio (n,w)
Belmont Smelting & Refining Works, Inc., NY (w)
Brooks & Perkins, Inc., Mich (z,cc,dd)
Copper & Brass Sales, Inc., Mich (o, z,bb,cc,dd,ee,ff)
Designers Metal Corp., Ill (cc)
Dow Chemical Co., Mich (n,o,q,w,z,aa,bb,cc,dd,ee)
Federated Metals Div., American Smelting & Refining Co., NY (n,w)
Hardy, Charles, Inc., NY (aa)
King Laboratories, Inc., NY (w,aa)
Kinkead Industries, Inc., Ill (cc,dd)
Light Metals, Inc., Ind (n)
Magline, Inc., Mich (o,z,bb,cc,ee,ff)
Magna Mfg. Co., Inc., NJ (aa)
Magnesium Elektron, Inc., NY (n, w,bb)
Magnode Products, Inc., Ohio (n,o,bb, dd,ee)
McGean Chemical Co., Ohio (aa)
Meier Brass & Aluminum Co., Mich (z)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Norrich Plastics Corp., NY (o,bb)
Nuclear Metals, Inc., Mass (bb,dd,ee)
Peerless Roll Leaf Co., Div. of Howe Sound Co., NJ (v,dd)
Plasmadyne Corp., Calif (aa)
Plasmatech Div., Valley Metallurgical Processing Co., Conn (aa)
Purdy, A.R. Co., Inc., NJ (o,z,bb,cc, ee,ff)
Reade Mfg. Co., Inc., NJ (aa)
Standard Magnesium Corp., Okla (n,q, w)
Tube Distributors Co., Inc., NY (ee)
Ullmann, Inc., Wis (o,ee)
U.S. Magnesium Div., Transition Metals & Chemicals, Inc., NY (aa)
Utica General Jobbing Foundry, Inc., NY (o)
Vanadium Corp. of America, NY (w)
Vitro Chemical Co., NY
Waltham Foundry Co., Mass (w)
White Metal Rolling & Stamping Corp., NY (n,o,q,z,bb,cc,dd,ee,ff)

Manganese and Its Alloys

Amalgamated Steel Corp., Ohio (o,bb)
American Nickel Alloy Mfg. Corp., NY (w)
Anaconda Co., NY (n,v,cc)
Belmont Smelting & Refining Works, Inc., NY (w,aa)
Chicago Development Corp., Md (o,v, z,bb,cc,dd,ee,ff)
Foote Mineral Co., Pa (aa)
Glidden Co., Chemical Divs., Metals Dept., Ind (aa)
Metals Dept., Pa (aa)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (ff)
Hommel, O. Co., Pa (aa)
Lavin, R. & Sons, Inc., Ill (w)
Metals Disintegrating Co., Inc., NJ (aa)
National Paint & Manganese Co., Va (aa)
National-U.S. Radiator Corp., Plastic Metals Div., NY (aa)
New Jersey Zinc Co., NY (w)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Pioneer Aluminum, Inc., Calif (z)
Taylor-Wharton Co., Div. of Harsco Corp., NJ (z,bb,ff)
Tube Distributors Co., Inc., NY (ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Utica General Jobbing Foundry, Inc., NY (aa)
Vanadium Corp. of America, NY (w)

Manganese Bronze

(see Copper)

Mechanical Fasteners

Abalon Precision Mfg. Corp., NY
Acme Stamping & Wire Forming Co., Pa
Albany Products Co., Inc., Conn
Allen Mfg. Co., Conn
Allmetal Screw Products Co., Inc., NY
Alofs Mfg. Co., Mich
Aluminum Co. of America, Pa
American Screw Co., Conn
American Steel and Wire Div., U.S. Steel Corp., Ohio
Anti-Corrosive Metal Products Co., Inc., NY
Atlantic Steel Co., Ga
Automatic Nut Co., Pa
Automotive Rubber Co., Inc., Mich
Aviation Developments, Inc., Calif
Bethlehem Steel Co., Pa
Blake & Johnson Co., Conn
Boots Aircraft Nut Corp., Conn
Bostitch, Inc., RI
C. E. M. Co., Inc., Conn
Camloc Fastener Corp., NJ
Central Screw Co., Ill
Champion Rivet Co., Ohio
Chicago Rivet & Machine Co., Ill
Chicago Screw Co., Div. of Standard Screw Co., Ill
Cleveland Cap Screw Co., Ohio
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif.
Consolidated Fruit Jar Co., NJ
Continental Screw Co., Mass
Delron Co., Inc., Calif
Dimco-Gray Co., Ohio
Driv-Lok Sales Corp., Ill
Elastic Stop Nut Corp. of America, NJ
Empire Spring Co., Ohio
Erie Bolt & Nut Co., Pa
Esco Corp., Ore
Falstrom Co., NJ
Fastex Div., Illinois Tool Works, Ill
General American Transportation Corp., Ill
General Chain & Mfg. Corp., Ohio
Gries Reproducer Corp., NY
—Ad p 468
Grip Nut Co., Sub. of Heli-Coil Corp., Ind.
Groov-Pin Corp., NJ
Harper, H.M. Co., Ill
Hartford Machine Screw Co., Div. of Standard Screw Co., Conn
Hassall, John, Inc., NY
Heli-Coil Corp., Conn
Hennefelt Precision Products, Inc., Fla
Hi-Shear Corp., Calif
Holo-Krome Screw Corp., Conn
Huck Mfg. Co., Mich
Hunter Corp., Pa
Hunter Spring Co. Div., American Machine & Metals, Inc., Pa
Ideal Can Co., Mass
Jaques Co., Mass
Jervis Corp., Mich
K S M Products, Inc., NJ
Kinkead Industries, Inc., Ill
Klincher Locknut Corp., Ind
Langsenkamp, F.H. Co., Ind
Lundquist Tool & Mfg. Co., Inc., Mass
MacLean-Fogg Lock Nut Co., Ill
Magnesium Products of Milwaukee, Inc., Wis
Meier Brass & Aluminum Co., Mich
Metal Goods Corp., Mo
Miracle Adhesives Corp., NY
Morrisville Foundry Co., Inc., Vt
National Lock Co., Fastener Div., Ill
National Machine Products Co., Mich
Navan Products, Inc., Sub. of North American Aviation Inc., Calif
Nelson Stud Welding Div., Gregory Industries, Inc., Ohio
Nutt-Shel Co., Calif
Nylok-Detroit, Mich
Ohio Nut & Bolt Co., Ohio
Palnut Co. Div., United-Carr Fastener Corp., NJ
Parker-Kalon Div., General American Transportation Corp., NJ
Penn Engineering & Mfg. Corp., Pa
Permali, Inc., Pa
Plastiglide Mfg. Corp., Calif
Plume & Atwood Mfg. Co., Conn
Prestole Corp, Ohio
Red Devil Mfg. Co., Ill
Republic Steel Corp., Ohio
Reynolds Aluminum Supply Co., Ga
Rhode Island Tool Co., RI
Robins Products Co., Mich
Rockwell Engineering Co., Ill
Rolled Alloys, Inc., Mich
Russell, Burdsall & Ward Bolt & Nut Co., NY
Set Screw & Mfg. Co., Ill
Shakeproof Div., Illinois Tool Works, Ill
Sharon Steel Corp., Pa
Shur-Lok Corp., Calif
Sillcocks Miller Co., NJ
Simmons Fastener Corp., NY
—Ad p 463
Simonsen Metal Products Co., Ill
Snyder Mfg. Co., Inc., Ohio
Southco Div., South Chester Corp., Pa
Southern Screw Co., NC
Special Screw Products Co., Ohio
Standard Locknut & Lockwasher, Inc., Ind
Standard Pressed Steel Co., Pa
Star Expansion Industries Corp., NY
Star Stainless Screw Co., NJ
Sterling Bolt Co., Ill
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala
Thompson-Bremer & Co., Ill
Thomson, Judson L. Mfg. Co., Mass
Tinnerman Products, Inc., Ohio
Townsend Co., Engineered Fasteners Div., Pa
Tubular Rivet & Stud Co., Mass
United Shoe Machinery Corp., Mass
—Ad p 465
United-Carr Fastener Corp., Mass
Velcro Sales Corp., NY
Waldes Kohinoor, Inc., NY
Waterbury Pressed Metal Co., Conn
Waterman Industries, Inc., Calif
Weckesser Co., Inc., Ill
Wesbar Stamping Corp., Wis
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio
Whitehead Metal Products Co., Inc., NY
Wilson, H.A. Div., Engelhard Industries, Inc., NJ
Worth Co., Wis

Melamines

Adhesive Products Corp., NY (x)
Alcylite Plastics & Chemical Corp., Calif (p,y)
Allied Chemical Corp., Plastics Div., NY (p,y)
American Cyanamid Co., Plastics & Resins Div., NY (p,x,y)
American-Marietta Co., Adhesive, Resin & Chemical Div., Wash (p)
Baer, N.S. Co., NJ (bb,cc,dd,ee)
Booty Resineers Div., American-Marietta Co., Ohio (p)
Cadillac Plastic & Chemical Co., Mich (bb,cc,dd,ee)
Caradco Corp., Durel Div., Iowa (cc)
Catalin Corp. of America, NY (p,x)
Colonial Kolonite Co., Ill (bb,cc,ee)
Comco Plastics, Inc., NY (bb,cc,dd,ee)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Curbell, Inc., NY (bb,cc,dd,ee)
Dapol Plastics, Inc., Mass (y)
Delta Plastics Co., NJ (bb,cc,dd,ee)
Dyna-Therm Chemical Corp., Calif (p)
Fiberite Corp., Minn (y)
Formica Corp., Sub. of American Cyanamid Co., Ohio (bb,cc,ee)
General Electric Co., Laminated Products Dept., Ohio (bb,cc,ee)
Grigoleit Co., Ill (p,s)
Haskelite Mfg. Div., Evans Products Co., Mich (dd)
Iten Fibre Co., Ohio (bb,cc,dd,ee)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Kurz Kasch, Inc., Ohio (y)
Laminated Plastex Corp., Ohio (x,cc)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (bb,cc)
Monsanto Chemical Co., Plastics Div., Mass
(p,x)—Ad pp 212-213
Muehlstein, H. & Co., Inc., NY (p,y)
National Vulcanized Fibre Co., Del (bb,cc,dd,ee)
Northern Plastics Corp., Wis (cc,dd)
Omni Products Corp., NY (y)
Panelyte Div., St. Regis Paper Co., NJ (x,bb,cc,dd,ee)
Penn Fibre & Specialty Co., Inc., Pa (bb,cc,dd,ee)
Philrus Products Co., NJ (bb,cc,dd,ee)
Reichhold Chemical, Inc., NY (p,x)
Richardson Co., NY (bb,cc,ee)
Sierra Electric Corp., Calif (y)
Spaulding Fibre Co., Inc., NY (bb,cc,dd,ee)
Synthane Corp., Pa (bb,cc,dd,ee)
Tanner Engineering Co., Calif (ee)
Taylor Fibre Co., Pa (bb,cc,dd,ee)
Texas Glass Fiber Corp., Tex (y)
U.S. Polymeric Chemical, Inc., Conn (s)
Westlake Plastics Co., Pa (bb,cc,dd,ee)

Metal Powder Parts

(Metal Compacts)

Allied Products Corp., Mich (c)
Aluminum Co. of America, Pa (a)
American Brake Shoe Co., NY (a,b,c,f,g,)
American Nickel Alloy Mfg. Corp., NY (f)
American Powdered Metals, Inc., Conn (b,c)
American Sinteel Corp., NY (b,c,d,g)
American Sinterings Div., Engineered Plastics, Inc., Conn (b,c,f,g,j)
Amplex Div., Chrysler Corp., Mich
(b,c,f,g)—Ad p 395
Arnold Engineering Co., Ill (c,f)
Arrow Sintered Products Co., Ill (b,c,g)
Asco Sintering Corp., Calif (a,b,c,d,f,g)
Atlas Brass Foundry, Calif (b,c)
Bassick Co., Conn (a,b,c,f,g)
Bendix Aviation Corp., NJ (a,b,c,f,g)
Boston Gear Works, Mass (a,b,c,f,g)
Bound Brook Bearing Corp. of America, NJ (b,c,f)
Brockway Pressed Metals, Inc., Pa (a,b,c,f,g)
Bunting Brass & Bronze Co., Ohio (b,c)
Burgess-Norton Mfg. Co., Ill (a,b,c,f,g)
Ceromet, Inc., Calif (b,c,f,g)
Chicago Development Corp., Md (h)
Chicago Powdered Metals Products Co., Ill (a,b,c,f,g)
Cleveland Graphite Bronze Div., Clevite Corp., Ohio (a,b,c,f,g)
Cleveland Metal Powder Co., Inc., Ohio (b,c,g)
Compacted Metals Corp., Ill (b,c,f,g)
CrystalX Corp., Pa (bb,cc,dd,ee)
Custom Tool & Mfg. Co., Minn
Delco Moraine Div., General Motors Corp., Ohio (b,c,f,g)
Dixon Sintaloy, Inc., Conn (b,c,f,g,h,j)
Eaton Mfg. Co., Powdered Metals Div., Mich (b,c,d,f,g,j)
Eberhart Steel Products, Powdered Metals Div., Ind (b,c)
Engineered Plastics & American Sinterings, Inc., Conn (b,c,f,g)
Esco Corp., Ore (f,g)
Ferro Powdered Metals, Inc., Ind (b,c,f,g)
General Astrometals Corp., NY (a,c,f)
General Metals Powder Co., Ohio (b,c,d,j)
General Powdered Metal Products, Inc., Holly Corp., Conn (a,b,c,f,g)
General Sintering Corp., Ill (a,b,c,f,g)
Gibson Electric Sales Corp., Pa (a,b,c,f)
Haller, Inc., Mich (b,c,g)
Indar Corp., Ind (a,b,c,f,g)
Indiana Steel Products Co., Ind (a,b,c,f,g)
International Powder Metallurgy Co., Inc., Pa (a,b,c,d,f,g,j)
Johnson Bronze Co., Pa (b,c)
Keystone Carbon Co., Pa (b,c,f,g)
Kwikset Powdered Metal Products, Calif (b,c,d,f,g)
Lux Clock Mfg. Co., Inc., Conn (a,b,c,f,g)
Magnetic Core Corp., NY (c)
Mallory, P.R. & Co., Inc., Ind (g)
Merriman Bros., Inc., Mass (b,c,f,g)
Metal Powder Products, Inc., Ohio (b,c,g)
Micro Metallic Corp., NY (a,b,c,f,g)
Micrometals, Calif (a,b,c,e,f)
Midwest Sintered Products Corp., Ill (b)
Mueller Brass Co., Mich
(a,b,c,f,g)—Ad p 404
National Molded Products, Inc., Pa (a,b,c,f,g)
National Moldite Co., NJ (c)
Norwalk Powdered Metals, Inc., Conn (b,c,f,g,j)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Nuclear Metals, Inc., Mass (a,b,c,e,f,g,h)
Pacific Sintered Metals Co., Calif (b,c,g)
Parker White Metal Co., Pa (b,c,f,g)
Picco, Inc., Calif (b,c)
Powder Metals Products Co., Pa (a,b,c,f,g)
Powdercraft Corp., SC (a,b,c,f,g)
Precision Metal Products Co., Pa (b,c)
Presmet Corp., Mass (b,c,f,g,l)
Pure Carbon Co., Inc., Pa (c)
Raybestos Div., Raybestos-Manhattan, Inc., Conn (a,b,c,e,f,h)
Reese Metal Products Corp., Pa (b,c,g)
Republic Steel Corp., Ohio (c)
Russell, Burdsall & Ward Bolt & Nut Co., NY (b,c,f,g)
Russell Mfg. Co., Conn (b)
St. Marys Carbon Co., Pa (b,c,f)
Schwarzkopf Development Corp., NY (a,b,c,e,f)
Sintercast Div., Chromalloy Corp., NY (a,c,f,g)
Sintered Metals, Inc., Mass (b,c)
Sparta Foundry Div., Muskegon Piston Ring Co., Mich (b,c)
Star Heel Plate Co., Inc., NJ (c)
Superior Carbon Products, Inc., Ohio (b,c,f,g)
Supermet Div., Globe Industries, Inc., Ohio (c,f,g)—Ad p 428
Torrington Co., Conn (a,b,f,g)
United Sintered Alloys, NY (a,b,c,f,g)
U.S. Graphite Co., Div. of Wickes Corp., Mich (b,c,d,f,g,l)
Uniworld Research Corp. of America, Ohio (c,f)
Veremere, E.A., Inc., Calif (a,b,c,f,g)
Wakefield Bearing Corp., Mass (b,c,f,g,h,l)
Wall Colmonoy Corp., Mich
Wellman, S.K. Co., Ohio (b,c)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (a,b,c,f,g,h)
Yale & Towne Mfg. Co., Powdered Metal Products Div., Ill (b,c)

Metallic Coatings

(see Diffusion Coatings; Immersion Coatings; Galvanizers; Electroplaters; Hard Facing Alloys; Preplated Metals; Metallized Coatings)

Metallized Coatings—Spray Metallizers

Alloy Products Corp., Wis
American Metal Products Co., Mich
Applied Instruments, Inc., NY
Bisonite Co., Inc., NY
Cerro Sales Corp., Sub. of Cerro Corp., NY
Continental Boiler & Sheet Iron Works, Mo
Custom Tool & Mfg. Co., Minn
Elmet Div., North American Phillips Co., Inc., Me
Farwell Metal Fabricating, Minn
Flood City Brass & Electric Co., Pa
Hayden Wire Works, Inc., Mass
Haynes Stellite Co., Div. of Union Carbide Corp., NY
Hunter Corp., Pa
Jema-American, Inc., NJ
Linde Co. Div., Union Carbide Corp., NY —Ad p 349
McGregor-Michigan Corp., Mich
Metal-Cladding, Inc., NY
Metallizing Co. of America, Ill
Metallizing Co. of Los Angeles, Inc., Calif
Metalweld, Inc., Pa
Metco Inc., NY
Moore Dry Dock Co., Calif
New Jersey Zinc Co., NY
Pabst Engineering Equipment Co., Inc., NJ
Parker White Metal Co., Pa
Plasmatech Div., Valley Metallurgical Processing Co., Conn
Sandy Hill Iron & Brass Works, NY
Schori Process Div., Ferro-Co Corp., NY
Schwartz Chemical Co., Inc., NY
Sealube Co., Mass
Southern Galvanizing Co., Md
Tickle, Arthur Engineering Works, Inc., NY
Wall Colmonoy Corp., Mich
Waterbury Cos., Inc., Conn
Zeller Corp., Ohio

Metallized Coatings—Vacuum Metallizers

Adams Plastic Products, Ohio
American Metal Climax, Inc., NY
American Metal Products Co., Mich
Amos Molded Plastics Div., Amos-Thompson Corp., Ind
Applied Instruments, Inc., NY
Avery Label Co., Calif
Bee Chemical Co., Ill
Closures, Inc., Conn
Coating Products, Inc., NJ
Cohan Epner Co., Inc., NY
Consolidated Vacuum Corp., NY
Cruver Mfg. Co., Ill
Davis Products Corp., NY
Dobeckmun Co., Div. of Dow Chemical Co., Ohio
Electrolizing Co., Ill
Electronic Parts Mfg. Co., Inc., NJ
Erie Resistor Corp., Plastics Div., Pa
Eyelet Specialty Div., International Silver Co., Conn
Felsenthal, G. & Sons, Ill
Gomar Mfg. Co., Inc., NJ
Hastings & Co., Inc., Pa
High Vacuum Equipment Corp., Mass
Industrial Paint Div., Glidden Co., Ohio
International Optical Co., Inc., NY
Jema-American, Inc., NJ
Kinney Vacuum Div., N. Y. Air Brake Co., Mass
Libbey-Owens-Ford Glass Co., Liberty Mirror Div., Pa
Metallizing Co. of America, Ill
Metaplast Process, Inc., NY
Mirra Cote Co., Inc., Calif
Nuclear Materials & Equipment Corp., Pa
Optical Coating Laboratory, Inc., Calif
Owens-Illinois Glass Co., Closure & Plastics Div., Ohio
Poly-Kote, Inc., Mass
St. Eloi Corp., Ohio
Schwartz Chemical Co., Inc., NY
Shelby Instrument Co., Calif
Superior Plastics, Inc., Ill
Swedlow, Inc., Calif
Sylvania Electric Products, Inc., NY
Vacuum Technology, Inc., Calif

Metallized Coatings—Metallizing Wire

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Alphaloy Corp., Div. of Alpha Metals, Inc., Ill
Belmont Smelting & Refining Works, Inc., NY
Carpenter Steel Co., Webb Wire Div., NJ
Colonial Alloys Co., Pa
Crucible Steel Co. of America, Pa
Electronic Parts Mfg. Co., Inc., NJ
Elmet Div., North American Phillips Co., Inc., Me
Empire Metal Co., NY
General Electric Co., Lamp Metals & Components Dept., Ohio
Hayden Wire Works, Inc., Mass
Hunter Corp., Pa
Marlane Development Co., Inc., NY
Metal Goods Corp., Mo
Metallizing Co. of America, Ill
Metallizing Co. of Los Angeles, Inc., Calif
Metco Inc., NY
National-Standard Co., Mich
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa
Roebling's, John A. Sons Div., Colorado Fuel & Iron Corp., NJ
Rotometals, Calif
Sandvik Steel, Inc., NJ
Stainless and Strip Div., Jones & Laughlin Steel Corp., Mich
Superior Mfg. Co., Pa
United Refining & Smelting Co., Ill
Uniworld Research Corp. of America, Ohio
Vanadium-Alloys Steel Co., Pa
White Metal Rolling & Stamping Corp., NY
Wright Metalcoaters, NJ

Methyl Methacrylate

(see Acrylic Plastics)

Mica

Asheville-Schoonmaker Mica Co., Va (r,z,aa,cc,ee)
Beryl Ores Co., Colo (z,aa,cc)
Brush Beryllium Co., Ohio (r)
Concord Mica Corp., NH (aa)
Continental-Diamond Fibre Corp., Del (r,z,cc,ee)
Edgar Plastic Kaolin Co., Fla (aa)
Farnam Mfg. Co., NC (r)
Foote Mineral Co., Pa (aa)
Franklin Mineral Products Co., NC (aa)
Funkhouser Mills, Div. of Ruberoid Co., Md (aa)
General Electric Co., NY (r)
Hall, C.P. Co., Ohio (aa)
Haveg Industries, Inc., Del (bb,cc)
Hayden Mica Co., Inc., Mass (aa)
Industrial Mica Corp., NJ (cc)
Insulation Mfrs. Corp., Ill (r,cc,ee)
Kassel Export Co., Inc., NJ (bb,ee)
McGean Chemical Co., Ohio (aa)
Mica Fabricating Co., NJ (r,aa,cc)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (z,cc,ee)
Micacraft Products, Inc., NJ (r,cc)
Mycalex Corp. of America, NJ (r,z,aa,bb,cc)—Ad p 320
Peerless Products Industries, Ill (r)
Richmond Mica Corp., Va (aa)
Smith Chemical & Color Co., Inc., NY (aa)
Sylvania Electric Products, Inc., Parts Div., Pa (r)
Synthetic Mica Co., Div. of Mycalex Corp. of America, NJ (aa)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
U.S. Mica Co., Inc., Ill (r)

Mineral Wool

(see Inorganic Fibers)

Molding Compounds

(see specific plastic or rubber)

Moldings, Blow

Adams Plastic Products, Ohio (k)
American Can Co., Plastics Div., NY (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (l)
Amos Molded Plastics Div., Amos-Thompson Corp., Ind (k)
Artmor Plastics Corp., Md (k)
Brown Rubber Co., Inc., Ind (m)
Cadillac Plastic & Chemical Co., Mich (k)
Campro Co., Ohio (k)
CrystalX Corp., Pa (k)
Davis, Joseph Plastics Co., NJ (k)
Dewitt Plastics, NY (k)
Eclipse Plastic Industries, Inc., Fla (k)
Faultless Rubber Co., Ohio (k,m)
Foster Grant Co., Mass (k)
General Plastics Corp., Ind (k)
General Plastics Mfg. Co., Wash (k,m)
Hohwieler Rubber Co., Inc., Pa (m)
Johnson Rubber Co., Ohio (m)
Lee Rubber & Tire Corp., Pa (m)
Lus-Trus Corp., Mich (k)
Luzerne Rubber Co., NJ (l)
Madin Plastics Inc., NJ (k)
Nalge Co., Inc., NY (k)
Newth Rubber Co., RI (m)
Olympic Plastics Co., Inc., Calif (k)
Owens Plastics Co., Mo (k,m)
Owens-Illinois Glass Co., Closure & Plastics Div., Ohio (k)
Plax Corp., Conn (k)
Rogers Corp., Conn (m)
Schwab Plastic Corp., Mich (k,m)
Seamless Rubber Co., Conn (m)
Shamban, W.S. & Co., Calif (k)
Sheller Mfg. Corp., Mich (l,m)
Stockwell Rubber Co., Inc., Pa (m)
Sun Rubber Co., Ohio (m)
Swedlow Inc., Calif (k,l)
Tuff Clad, Inc., Ohio (k)
Universal Unlimited, Inc., NY (k)
Wasco Products, Inc., Mass (k)
Western Felt Works, Ill (l,m)
Westlake Plastics Co., Pa (k)
Whyte Mfg. Co., Inc., NY (k,m)
Woodall Industries Inc., Mich

Moldings, Cold

Acushnet Process Co., Mass (m)
American Hard Rubber Co., Div. of Amerace Corp., NJ (l)
American Insulator Corp., Pa (l)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Biggs, Carl H. Co., Inc., Calif (l)
Calfibe, Co., Inc., Calif (l)
Cellcote Co., Ohio (l)
Dryden Rubber Div., Sheller Mfg. Co., Ill (m)
Enflo Corp., NJ (l)
Foss Mfg. Co., Id (l)
Garfield Mfg. Co., NJ (l)
Garlock Packing Co., NY (k,m)
Halex Corp., Mich (k)
Hohwieler Rubber Co., Inc., Pa (m)
Modern Industrial Plastics Div., Duriron Co., Ohio (l)
Raybestos Div., Raybestos-Manhattan, Inc., Conn (l)
Rostone Corp., Ind (l)
Seamless Rubber Co., Conn (m)
Schori Process Div., Ferro-Co Corp., NY (l)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Tri-Point Plastics, Inc., NY (k)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (l)
Warminster Fiberglass Co., Div. of Fischer & Porter Co., Pa (l)

Moldings, Compression

Acadia Synthetic Products Div., Western Felt Works, Ill (m)
Ackerman Plastic Molding Div., Consolidated Iron-Steel Mfg. Co., Ohio (l)
Acushnet Process Co., Mass (m)
Admiral Corp., Molded Products Div., Ill (l)
Aerojet-General Corp., Structural Materials Div., Calif (l)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (l)
Alcylite Plastics & Chemical Corp., Calif (l)
Alden Products Co., Mass (l)
Allegheny Plastics, Inc., Pa (k)
Allied Resinous Products, Inc., Ohio (k)
American Agile Corp., Ohio (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l,m)
American Insulator Corp., Pa (l)—Ad p 433
American Plastics Corp., NY (l)
American Sinterings Div., Engineered Plastics, Inc., Conn (l)
Anderson Assoc., Inc., Ohio (l)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Aries Laboratories, Inc., Conn (l)
Armstrong Cork Co., Pa (l)
Artmor Plastics Corp., Md (k,l)

Atlantic India Rubber Works, Inc., Ill (m)
Auburn Mfg. Co., Conn (k,m)
Auburn Plastics, Inc., NY (k,l)
Automotive Rubber Co., Inc., Mich (m)
Bangor Plastics Inc., Mich (l)
Beck, I. & Sons, Inc., NY (k)
Belko Corp., Md (m)
Boonton Molding Co., NJ (k)
Bolta Products Div., General Tire & Rubber Co., Mass (l)
Button Corp. of America, NJ (l)
Cadillac Plastic & Chemical Co., Mich (k)
Camfield Fiberglass Plastics, Inc., Mich (l)
Canfield, H.O. Co., Va (l,m)
Capac Mfg. Corp., Mich (l,m)
Chemtrol, Calif (k)
Chicago Gasket Co., Ill (l)
Chicago Molded Products Corp., Ill (l)
Chicago Molded Products Corp., Custom Molding Div., Ill (l)
Chicago Rawhide Mfg Co., Ill (k,m)
Chicago-Allis Mfg. Corp., Ill (m)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio
(k,m)—Ad p 416
Colt's Plastics Co., Inc., Conn (l,m)
Connecticut Hard Rubber Co., Conn (m)
Consolidated Molded Products Corp., Pa (l)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
Cosmo Plastics Co., Ohio (k)
Crane Packing Co., Ill (k)
Curtiss-Wright Corp., Plastics Div., NY (l)
Curtiss-Wright Corp., Utica Div., Mich (l)
Davidson Rubber Co., Mass (l,m)
Dayco Corp., Ohio (m)
Delta Plastics Co., NJ (l)
Dimco-Gray Co., Ohio (l)
Disogrin Industries, NY (m)
Doré, John L., Inc., Tex (l)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (k)
Dumont Corp., Calif (l)
Duriron Co., Inc., Ohio (l)
Electronic Production & Development, Inc., Chemical Div., Calif (l)
Enflo Corp., NJ (l)
Fabricon Products Div., Eagle-Picher Co., Mich (l)
Faultless Rubber Co., Ohio (k,m)
Fiber Glass Industries, Inc., NY (l)
Fibercast Div., Youngstown Sheet & Tube Co., Okla (l)
Fiberglass Ohio Inc., Ohio (l)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (l,m)
Firestone Tire & Rubber Co., Ohio (m)
Formica Corp., Sub. of American Cyanamid Co., Ohio (l)
Garfield Mfg. Co., NJ (l)
Garlock Packing Co., NY (k,m)
Gatke Corp., Ill (l)
Geauga Industries Co., Ohio (m)
General American Transportation Corp., Ill (k,l)
General American Transportation Corp., Plastics Div., Ill (k,l)
General Electric Co., Chemical & Metallurgical Div., Ill (l)
General Electric Co., Plastics Dept., Ill (l,m)
General Gasket, Inc., Conn (m)
General Industries Co., Molded Plastic Div., Ohio (l)
Gisholt Plastics, Wis (l)
Glass Reinforced Plastics Corp., Ohio (l)
Glastic Corp., Ohio (l)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Goshen Rubber Co., Inc., Ind (m)
Greene, Tweed & Co., Pa (k,l,m)
Grimes Mfg. Co., Plastic Research Products Div., Ohio (l)
Halogen Insulator & Seal Corp., Ill (l)
Haveg Industries, Inc., Del (l)
Hawkeye Rubber Mfg. Co., Iowa (m)
Hawley Products Co., Ill (l)
Hays Mfg. Co., Pa (l)
Hohwieler Rubber Co., Inc., Pa (m)
Houston Reinforced Plastics Co., Inc., Tex (l)
Industrial Molded Products Co., Inc., Ill (l)
Industrial Products Div., General Tire & Rubber Co., Ind (m)
Insulation Products Co., Pa (l)
International Packings Corp., NH
(m)—Ad p 435
Jersey Plastic & Die Casting Co., NJ (l)
Johnson Rubber Co., Ohio (m)
Judsen Rubber Works, Inc., Ill (m)
Kerrco, Neb (k,l)
Kirkhill Rubber Co., Calif (m)
Kuhn & Jacob Molding & Tool Co., NJ (l)
Kurz Kasch, Inc., Ohio (l)
Lamtex Industries, Inc., NY (l)
Lavelle Rubber Co., Ill (m)
Lee Rubber & Tire Corp., Pa (m)
Lewis, G.B. Co., Wis
(l)—Ad p 434
Lone Star Plastics Co., Inc., Tex (l)
Loranger Mfg. Corp., Pa (l)
Lunn Laminates, Inc., NY (l)
Luzerne Rubber Co., NJ (k,l)
Mack Molding Co., NJ (l)
Maloney, F.H. Co., Tex (l,m)
Martin Rubber Co., Inc., NJ (m)
Mesa Plastics Co., Calif (l)
Micarta Div., Westinghouse Electric Corp., SC (k,l,m)
Mid-States Rubber Products, Inc., Ind (m)
Midwest Molding & Mfg. Co., Ill (l)
Midwest Rubber Co., Mich (m)
Minneapolis Plastic Molders, Inc., Minn (l)
Minnesota Rubber Co., Minn (m)
Modern Industrial Plastics Div., Duriron Co., Ohio (l)
Modern Plastics Corp., Mich (l)
Molded Fiber Glass Co., Ohio (l)
Morrell, George Corp., Mich (l)
Moxness Products, Inc., Wis
(l,m)—Ad p 302
National Lock Co., Ill (l)
Newth Rubber Co., RI (m)
Olympic Plastics Co., Inc., Calif (l)
Owens-Illinois Glass Co., Closure & Plastics Div., Ohio (l)
Pacific Moulded Products Corp., Calif (m)
Paeco Rubber Co., Inc., Ohio (k,l,m)
Pam-Pro Plastics, Calif (l)
Panelyte Div., St. Regis Paper Co., NJ
(l)—Ad p 410
Parker Appliance Co., Rubber Products Div., Ohio (m)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (m)
Parker, Stearns & Co., Inc., NY (m)
Perry Plastics, Inc., Pa (k,l)
Plastic & Rubber Product Co., Calif (m)
Plastic Masters, Inc., Mich (l)
Plastic Products Corp., Ohio (l)
Polymer Corp., Pa (k)
Precision Rubber Products Corp., Ohio (m)
Raybestos-Manhattan, Inc., NJ (l,m)
Regal Plastic Co., Mo (l)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Richardson Co., NY (l)
Riverside Plastics Corp., NY (l)
Roberts Toledo Rubber Co., Ohio (m)
Rogers Corp., Conn (l,m)
Rogers, V.F. Plastic Molding, Colo (l,m)
Romar Plastics, Inc., Ill (l)
Rostone Corp., Ind (l)
Roth Rubber Co., Ill (m)
Russell Reinforced Plastics Corp., NY (l)
St. Clair Rubber Co., Mich (m)
Sealview Plastics, Inc., Pa (l)
Shamban, W.S. & Co., Calif (k)
Shaw Insulator Co., NJ (l)
Sheller Mfg. Corp., Mich (k,l,m)
Sierra Electric Corp., Calif (l)
Sierra Engineering Co., Calif (m)
Sillcocks Miller Co., NJ (k)
Southern Plastics Co., SC (l)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Spencer Rubber Co., Conn (m)
Stalwart Rubber Co., Ohio (m)
Standard Plastics Co., Mass (l)
Stillman Rubber Co., Calif
(m)—Ad p 415
Stockwell Rubber Co., Inc., Pa (k,l,m)
Stokes Molded Products Div., Electric Storage Battery Co., NJ (l)
Stowe-Woodward, Inc., Mass (m)
Structural Fibers, Inc., Ohio (l)
Sun Rubber Co., Ohio (m)
Swedish Crucible Steel Co., Mich (k)
Swedlow, Inc., Calif (l)
Sylvania Electric Products, Inc., Parts Div., Pa (l)
Synthane Corp., Pa (l)
Tanner Engineering Co., Calif (l)
Taunton Div., Haveg Industries, Inc., Mass (k,l,m)
Texstar Plastics Div., Texstar Corp., Tex (k,l)
Thermoid Div., H.K. Porter Co., Pa (l)
Thompson, H. I. Fiber Glass Co., Calif (l)
Tingley Rubber Corp., NJ (m)
Toledo Industrial Rubber Co., Ohio (l,m)
Toyad Corp., Pa (k,m)
Tri-Point Plastics, Inc., NY (k)
Trostel, Albert Packing, Ltd., Wis (m)
Tyer Rubber Co., Mass (m)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (k,l)
U.S. Stoneware Co., NY (k,l)
Vulcanized Rubber & Plastics Co., Pa (m)
Waldman, Joseph & Sons, Epoxy Products Div., NJ (l)
Warminster Fiberglass Co., Div. of Fischer & Porter Co., Pa (l)
Waterbury Cos., Inc., Conn (l)
Wesbar Stamping Corp., Wis (m)
Western Felt Works, Ill (l,m)
Westlake Plastics Co., Pa (k)
Whitso, Inc., Ill (l)
Williams - Bowman Rubber Co., Ill
(l,m)—Ad p 422
Wittman, Lawrence & Co., NY (l)
Woodall Industries, Inc., Mich (l)
Wyatt Industries Inc., Plastic & Rubber Div., Tex (l,m)
Yale Rubber Mfg. Co., Mich (m)
Zenith Plastics Co., Calif (l)

Moldings, Injection

aaRBee Plastic Co., Calif (k)
Acadia Synthetic Products Div., Western Felt Works, Ill (m)
Acushnet Process Co., Mass (m)
Adams Plastic Products, Ohio (k)
Admiral Corp., Molded Products Div., Ill (k)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (k)
Alden Products Co., Mass (k)
American Agile Corp., Ohio (k)
American Can Co., Plastics Div., NY (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,m)
American Insulator Corp., Pa (k,m)
American Plastics Corp., NY (k)
Amos Molded Plastics Div., Amos-Thompson Corp., Ind (k)
Anderson Assoc., Inc., Ohio (k)
Anthes Div., Gleason Corp., Iowa (k,l)
Armstrong Cork Co., Pa (k)
Auburn Mfg. Co., Conn (k,m)
Auburn Plastics, Inc., NY (k,m)
Auburn Rubber Co., Inc., Ind (k)
Belko Corp., Md (m)
Bolta Products Div., General Tire & Rubber Co., Mass (k)
Booker & Wallestad, Inc., Minn (k)
Boonton Molding Co., NJ (k)
Bridgeport Moulded Products, Inc., Conn (k)
Buckeye Molding Co., Ohio (k)
Burwood Products Co., Mich (k)
Byrd Plastics, Inc., Pa (k)
Cambridge-Panelyte Molded Plastics Co., Div. of St. Regis Paper Co., Ohio (k)
Campro Co., Ohio (k)
Canfield, H.O. Co., Va (l,m)
Carlon Products Corp., Ohio (k)
Celluplastic Corp., NJ (k)
Chemtrol, Calif (k)
Chicago Molded Products Corp., Ill (k)
Chicago Molded Products Corp., Custom Molding Div., Ill (k)
Chicago-Allis Mfg. Corp., Ill (m)
Clover Industries, Inc., NY (k)
Colonial Plastics Mfg. Co., Div. of Van Dorn Iron Works Co., Ohio (k)
Colt's Plastics Co., Inc., Conn (k)
Comet Metal Products Co., Inc., NY (k)
Commercial Plastics Co., Ill (k)
Commercial Plastics Co., Associated Plastic Div., Mich (k)
Consolidated Molded Products Corp., Pa (k)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k)
Cosmo Plastics Co., Ohio (k)
Cruver Mfg. Co., Ill (k)
CrystalX Corp., Pa (k)
Curtiss-Wright Corp., Plastics Div., NY (k)
Danielson Mfg. Co., Conn (k)
Dapol Plastics, Inc., Mass (k,l)
Dayton Rogers Mfg. Co., Minn (k,l)
Delta Plastics Co., NJ (k)
Denver Plastics, Inc., Colo (k)
Detroit Macoid Corp., Mich (k,m)
Doré, John L. Co., Tex (l)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (k,m)
Electronic Production & Development, Inc., Chemical Div., Calif (k)
Engineered Nylon Products Div., Kennatrack Corp., Ind (k)
Erie Resistor Corp., Plastics Div., Pa (k)
Fabricon Products Div., Eagle-Picher Co., Mich (k)
Federal Tool Corp., Ill (k)
Felsenthal, G. & Sons, Ill (k)
Fiberglass Ohio Inc., Ohio (l)
Foster Grant Co., Mass (k)
Galigher Co., Utah (k,l)
Garlock Packing Co., NY (k)
Geauga Industries Co., Ohio (m)
General American Transportation Corp., Ill (k)
General American Transportation Corp., Plastics Div., Ill (k)
General Electric Co., Chemical & Metallurgical Div., Ill (k)
General Electric Co., Plastics Dept., Ill (k)
General Industries Co., Molded Plastic Div., Ohio (k)
Glass Laboratories, Inc., NY (k)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Gossett and Hill Co., Ill (k)
Gotham Plastics Corp., NY (k)
Gries Reproducer Corp., NY (k)
Hadbar, Inc., Calif (k)
H & R Plastics Industries, Inc., Pa (k)
Hauser Products, Inc., Ill (l)
Hewitt-Robins, Inc., Conn (m)
Hungerford Plastics Corp., NJ (k,m)
Industrial Molded Products Co., Inc., Ill (k)
Jamison Plastic Corp., NY (k)
Jersey Plastic & Die Casting Co., NJ (k)
Jet Specialties Co., Inc., Calif (k)
Johnson Plastic Corp., Ohio (k,m)
Judson Rubber Works, Inc., Ill (m)
Keolyn Plastics, Inc., Ill (k)
Kerrco, Neb (k,l)
Kirk, F.J. Co., Inc., Mass (k)
Lancaster Glass Corp., Ohio (k)
Lee Rubber & Tire Corp., Pa (m)
Lincoln Molded Plastics, Inc., Ohio (k)
Lone Star Plastics Co., Inc., Tex (k)
Loranger Mfg. Corp., Pa (k)
Luminous Resins, Inc., Ill (k)
Luzerne Rubber Co., NJ (k)
Mack Molding Co., NJ (k)
Madin Plastics Inc., NJ (k)
Mallory, P.R. Plastics, Inc., Ill (k)
Maloney, F.H. Co., Tex (k)
Michigan Plastic Products, Inc., Mich (k)
Midwest Molding & Mfg. Co., Ill (k)
Minneapolis Plastic Molders, Inc., Minn (k)
Minnesota Plastics Corp., Minn (k,m)
Minnesota Rubber Co., Minn (m)
Mirro Cote Co., Inc., Calif (k)
Modern Industrial Plastics Div., Duriron Co., Ohio (k)
Modern Plastics Corp., Mich (k)
Moxness Products, Inc., Wis (k)
Nalge Co., Inc., NY (k)
National Lock Co., Ill (k)
Norgren-Stemac, Inc., Colo (k)
Nosco Plastics Co., Pa (k)
Nylon Molded Products Corp., Ohio (k)
Nyloncraft, Inc., Ind (k)
Ohio Rubber Co., Ohio (k)
Olympic Plastics Co., Inc., Calif (k)
O'Sullivan Rubber Corp., Va (k)—Ad p 215
Owens-Illinois Glass Co., Closure & Plastics Div., Ohio (k)
Paeco Rubber Co., Inc., Ohio (k,l,m)
Pam-Pro Plastics, Calif (k)
Panelyte Div., St. Regis Paper Co., NJ (k)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (m)
Pee Wee Molding Corp., NY (k)
Peoria Plastic Co., Ill (k)
Perfex Plastics, Inc., Ill (k)
Perry Plastics, Inc., Pa (k,l)
Pipco International Corp., Sub. of Plastiglide Mfg. Corp., Calif (k)
Plastic Engineering, Inc., Ohio (k)
Plastic Masters, Inc., Mich (k)
Plastiglide Mfg. Corp., Calif (k)
Plax Corp., Conn (k)
Plymouth Industrial Products, Wis (k)
Porter, William Co., Calif (k)
Precision Plastics Co., Pa (k)
Presque Isle Plastics, Inc., Pa (k)
Prince Rubber & Plastics Products, Inc., NY (k,l)
Pyramid Products Co., Inc., Ohio (k)
Pyro Plastics Corp., NJ (k)
Quinn-Berry Corp., Pa (k)
Raybestos-Manhattan, Inc., NJ (m)
Roberts Toledo Rubber Co., Ohio (m)
Rogers, V.F. Plastic Molding, Colo (k)
Romar Plastics, Inc., Ill (k)
Russell, Burdsall & Ward Bolt & Nut Co., NY (k)
St. Clair Rubber Co., Mich (m)
Sanford Plastics Corp., NY (k)
Santay Corp., Ill (k)
Saran Lined Pipe Co., Div. of Michigan Pipe Co., Mich (k)
Schaefer-Hausner Corp., NY (k)
Schwab Plastic Corp., Mich (k)
Shamban, W.S. & Co., Calif (k)
Shaw Insulator Co., NJ (k)
Sheller Mfg. Corp., Mich (k,l,m)
Sierra Electric Corp., Calif (k)
Sillcocks Miller Co., NJ (k)
Sinko Mfg. & Tool Co., Ill (k)
Standard Plastics Co., Mass (k)
Sterling Molders, Inc., NY (k)
Stockwell Rubber Co., Inc., Pa (m)
Stillman Rubber Co., Calif (m)
Superior Plastics, Inc., Ill (k)
Sylvania Electric Products, Inc., Parts Div., Pa (k)
Tanner Engineering Co., Calif (k)
Taunton Div., Haveg Industries, Inc., Mass (k)
Tingley Rubber Corp., NJ (k)
Toledo Industrial Rubber Co., Ohio (l, m)
Tri-Point Plastics, Inc., NY (k)
Tri-State Plastic Molding Co., Ky (k)
Tube Turns Plastics, Inc., Ky (k)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (k)
United-Carr Fastener Corp., Mass (k,l)
Vulcanized Rubber & Plastics Co., Pa (k,m)
Wagner Plastic Corp., NJ (k)
Waterbury Cos., Inc., Conn (k)
Western Felt Works, Ill (l,m)
Westlake Plastics Co., Pa (k)
Whyte Mfg. Co., Inc., NY (k,m)
Worcester Moulded Plastics Co., Mass (k)
Zenith Plastics Co., Calif (l)

Moldings, Reinforced Plastics

(see Laminates)

Moldings, Sheet

(sheet formed parts)

Allied Resinous Products, Inc., Ohio (k)
American Agile Corp., Ohio (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l)
American Plastics Corp., NY (k)
American Polyglas Corp., NJ (l)
Ames Molded Plastics Div., Amos-Thompson Corp., Ind (k)
Artmor Plastics Corp., Md (k)
Auburn Rubber Co., Inc., Ind (k)
Blank, Arthur & Co., Inc., Mass (k)
Borkland Mfg. Co., Ind (k)
Brown Rubber Co., Inc., Ind (m)
Butler Mfg. Co., Mo (k)
Cadillac Plastic & Chemical Co., Mich (k,l)
Cambridge-Panelyte Molded Plastics Co., Div. of St. Regis Paper Co., Ohio (k)
Canfield, H.O. Co., Va (l,m)
Carolina Industrial Plastics Div., Essex Wire Corp., NC (k)
Carroll, J.B. Co., Ill (k)
Chicago-Allis Mfg. Corp., Ill (m)
Cincinnati Industries Inc., Ohio (k)
Colonial Art Co., Inc., Mass (k)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio (k,m)
Connecticut Hard Rubber Co., Conn (m)
Consolidated Molded Products Corp., Pa (k)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
CrystalX Corp., Pa (k)
Curbell, Inc., NY (k)
Dewitt Plastics, NY (k)
Duplican Corp., Mass (k)
Dryden Rubber Div., Sheller Mfg. Co., Ill (m)
Dura Plastics of New York, Inc., NY (k)
Enflo Corp., NJ (l)
Fabricon Products Div., Eagle-Picher Co., Mich (l)
Falge Engineering Corp., Md (k)
Faultless Rubber Co., Ohio (m)
Federal Tool Corp., Ill (k)
Fiber Glass Industries, Inc., NY (l)
Formica Corp., Sub. of American Cyanamid Co., Ohio (l)
Foster Grant Co., Mass (k)
Fry Plastics International, Calif (k)
Galigher Co., Utah (k)
Garlock Packing Co., NY (k,m)
General American Transportation Corp., Ill (k)
General American Transportation Corp., Plastics Div., Ill (k)
General Electric Co., Chemical & Metallurgical Div., Ill (m)
General Plastics Corp., Ind (k)
General Plastics Mfg. Co., Wash (k,m)
General Tire & Rubber Co., Ind (l)
Glastic Corp., Ohio (l)
Hadbar, Inc., Calif (m)
H & R Plastics Industries, Inc., Pa (k)
Haveg Industries, Inc., Del (l)
Hays Mfg. Co., Pa (l)
Heil Process Equipment Corp., Ohio (k,l,m)
Hewitt-Robins, Inc., Conn (m)
Hohwieler Rubber Co., Inc., Pa (m)
Klise Mfg. Co., Mich (k)
Lone Star Plastics Co., Inc., Tex (k)
Luminous Resins, Inc., Ill (k)
Luna Laminates, Inc., NY (k,l)
Lus-Trus Corp., Mich (k)
Luzerne Rubber Co., NJ (k,l)
Madin Plastics Inc., NJ (k)
Marblette Corp., NY (l)
Mica Insulator Co., NY (l)
Micarta Div., Westinghouse Electric Corp., SC (k,l)
Midwest Plastic Products Co., Ill (k)
Minnesota Mining & Mfg. Co., Minn (l)
Nalge Co., Inc., NY (k)
National Vulcanized Fibre Co., Del (l)
Newth Rubber Co., RI (m)
Nopco Chemical Co., NJ (l)
O'Sullivan Rubber Corp., Va (k)—Ad p 215
Pam-Pro Plastics, Calif (k)
Panelyte Div., St. Regis Paper Co., NJ (k)
Plastic & Rubber Products Co., Calif (m)
Plastic Products Corp., Ohio (k)
Pyro Plastics Corp., NJ (k)
Pyrosil, Inc., Ohio (l)
Quelcor, Inc., Pa (k)
Regal Plastic Co., Mo (k)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Rogers Corp., Conn (l,m)
St. Clair Rubber Co., Mich (m)
Schori Process Div., Ferro-Co Corp., NY (l)
Sealview Plastics, Inc., Pa (k)
Seamless Rubber Co., Conn (m)
Shamban, W.S. & Co., Ind (k)
Sierra Electric Corp., Calif (k,l)
Sillcocks Miller Co., NJ (k)
Snyder Mfg. Co., Inc., Ohio (k)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Strick Plastic Co., Pa (k,m)
Superior Plastics, Inc., Ill (k)
Swedlow, Inc., Calif (k,l)
Synthane Corp., Pa (l)
Taunton Div., Haveg Industries, Inc., Mass (m)
Texstar Plastics Div., Texstar Corp., Tex (k,l)
Toyad Corp., Pa (k)
Tri-Point Plastics, Inc., NY (k)
Tuff Clad, Inc., Ohio (k)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (k,l)
Universal Unlimited, Inc., NY (k)
Valley-National Corp., Conn (k)
Vulcan Div., Reeves Bros. Inc., NY (m)
Western Felt Works, Ill (l,m)
Westlake Plastics Co., Pa (k)
Williams-Bowman Rubber Co., Ill (l, m)
Woodall Industries, Inc., Mich

Moldings, Slush

(plastics and rubber)

American Agile Corp., Ohio (k)
Automotive Rubber Co., Inc., Mich (m)
Boonton Molding Co., NJ (m)
Borden Co., Borden Chemical Div., NY (k)
Chicago-Allis Mfg. Corp., Ill (m)
Dennis Chemical Co., Mo (k)
Douglas & Sturgess, Calif
Dryden Rubber Div., Sheller Mfg. Corp., Ill (k)
Hungerford Plastics Corp., NJ (k,m)
Madin Plastics Inc., NJ (k)
Munray Products Div., Fanner Mfg. Co., Ohio (k,l,m)
Pyrosil, Inc., Ohio (l)
Quelcor, Inc., Pa (k)
Sheller Mfg. Corp., Mich (k,l,m)
Steere Enterprises, Inc., Ohio (m)—Ad p 351
Tuff Clad, Inc., Ohio (k)
U.S. Stoneware Co., Ohio (k)
Western Textile Products Co., Mo (k,m)

Moldings, Transfer

Accurate Molding Corp., NY (l)
Acushnet Process Co., Mass (m)
Admiral Corp., Molded Products Div., Ill (l)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (l)
Alcylite Plastics & Chemical Corp., Calif (l)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l)
American Insulator Corp., Pa (l)—Ad p 433
American Plastics Corp., NY (l)
American Sinterings Div., Engineered Plastics, Inc., Conn (l)
Auburn Mfg. Co., Conn (k)
Auburn Plastics, Inc., NY (l)
Automotive Rubber Co., Inc., Mich (m)
Bangor Plastics, Inc., Mich (l)
Belko Corp., Md (m)
Biwax Corp., Ill (l)
Bond International, Inc., Mich (m)
Booker & Wallestad, Inc., Minn (l)
Boonton Molding Co., NJ (k)
Bridgeport Moulded Products, Inc., Conn (l)
Canfield, H.O. Co., Va (l,m)
Capac Mfg. Corp., Mich (l,m)
Chicago Molded Products Corp., Ill (l)
Chicago Molded Products Corp., Custom Molding Div., Ill (l)

Chicago Rawhide Mfg. Co., Ill (k,m)
Chicago-Allis Mfg. Corp., Ill (m)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio (k,m)—Ad p 416
Colt's Plastics Co., Inc., Conn (l)
Consolidated Molded Products Corp., Pa (l)
Continental Rubber Works, Pa (m)
Dayco Corp., Ohio (m)
Dayco Corp., Molded Products Div., Mich (l)
Dayton Rogers Mfg. Co., Minn (k,l)
Delta Plastics Co., NJ (l)
Dimco-Gray Co., Ohio (l)
Disogrin Industries, NY (m)
Doré, John L. Co., Tex (l)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (k)
Electronic Production & Development, Inc., Chemical Div., Calif (l)
Faultless Rubber Co., Ohio (m)
Fiberglass Ohio Inc., Ohio (l)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (m)
Formica Corp., Sub. of American Cyanamid Co., Ohio (k)
Galigher Co., Utah (m)
Garfield Mfg. Co., NJ (l)
Garlock Packing Co., NY (k,m)
General American Transportation Corp., Ill (k,l)
General American Transportation Corp., Plastics Div., Ill (l)
General Electric Co., Chemical & Metallurgical Div., Ill (l)
General Electric Co., Plastics Dept., Ill (l,m)
General Industries Co., Molded Plastic Div., Ohio (l)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Grimes Mfg. Co., Plastic Research Products Div., Ohio (l)
Haveg Industries, Inc., Del (l)
Hawkeye Rubber Mfg. Co., Iowa (m)
Hohwieler Rubber Co., Inc., Pa (m)
Houghton, E.F. & Co., Pa (m)
Houston Reinforced Plastics Co., Inc., Tex (l)
Industrial Molded Products Co., Inc., Ill (l)
Insulation Products Co., Pa (l)
Johnson Rubber Co., Ohio (m)
Judsen Rubber Works, Inc., Ill (m)
Kerrco, Neb (k,l)
Kurz Kasch, Inc., Ohio (l)
Lee Rubber & Tire Corp., Pa (m)
Lone Star Plastics Co., Inc., Tex (l)
Loranger Mfg. Corp., Pa (l)
Luzerne Rubber Co., NJ (k,l)
Mack Molding Co., NJ (l)
Marion Div., General Tire & Rubber Co., Ind (l)
Martin Rubber Co., Inc., NJ (m)
Mesa Plastics Co., Calif (l)
Mid-States Rubber Products, Inc., Ind (m)
Midwest Molding & Mfg. Co., Ill (l)
Minnesota Rubber Co., Minn (l,m)
Moxness Products, Inc., Wis (l,m)
National Lock Co., Ill (l)
Olympic Plastics Co., Inc., Calif (l)
Paeco Rubber Co., Inc., Ohio (k,l,m)
Pam-Pro Plastics, Calif (l)
Panelyte Div., St. Regis Paper Co., NJ (l)
Parker Appliance Co., Rubber Products Div., Ohio (m)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (m)
Perry Plastics, Inc., Pa (l)
Plastic & Rubber Products Co., Calif (m)
Plastic Research Products Co., Div. of Grimes Mfg. Co., Ohio (l)
Porter, William Co., Calif (l)
Precision Rubber Products Corp., Ohio (m)
Raybestos-Manhattan, Inc., NJ (m)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Richardson Co., NY (l)
Rogers, V.F. Plastic Molding, Colo (l,m)
Romar Plastics, Inc., Ill (l)
Rostone Corp., Ind (l)
Roth Rubber Co., Ill (m)
St. Clair Rubber Co., Mich (m)
Seamless Rubber Co., Conn (m)
Shaw Insulator Co., NJ (l)
Sheller Mfg. Corp., Mich (k,l,m)
Sierra Electric Corp., Calif (l)
Sierra Engineering Co., Calif (m)
Southern Plastics Co., SC (l)
Standard Plastics Co., Mass (l)
Stillman Rubber Co., Calif (m)—Ad p 415
Stockwell Rubber Co., Inc., Pa (m)
Stowe-Woodward, Inc., Mass (m)
Sun Rubber Co., Ohio (m)
Sylvania Electric Products, Inc., Parts Div., Pa (l)
Tanner Engineering Co., Calif (l)
Taunton Div., Haveg Industries, Inc., Mass (k,l,m)
Tingley Rubber Corp., NJ (m)
Toledo Industrial Rubber Co., Ohio (l,m)
Tri-Point Plastics, Inc., NY (k)
Trostel, Albert Packing, Ltd., Wis (m)
Vulcanized Rubber & Plastics Co., Pa (m)
Waldman, Joseph & Sons, Epoxy Products Div., NJ (l)
Waterbury Cos. Inc., Conn (l)
Western Felt Works, Ill (l,m)
Whitso, Inc., Ill (l)
Williams-Bowman Rubber Co., Ill (l,m)—Ad p 422
Wyatt Industries Inc., Plastic & Rubber Div., Tex (l,m)

Molybdenum and Its Alloys

Alloy Metal Products, Inc., Iowa (o,w)
Alpha Metals, Inc., NJ (cc,dd)
Amalgamated Steel Corp., Ohio (o,bb)
American Metal Climax, Inc., NY (o,q,z,aa,bb,cc,dd)
American Nickel Alloy Mfg. Corp., NY (w,aa)
American Silver Co., NY (v,dd,ee,ff)
Associated Engineering & Mfg. Corp., NJ (n,o,aa,bb,cc,dd,ee,ff)
Belmont Smelting & Refining Works, Inc., NY (o,w,aa)
Cleveland Tungsten Inc., Ohio (aa,bb, ee)
Climax Molybdenum Div., American Metal Climax, Inc., NY (o,q,w,bb,cc)
Crucible Steel Co. of America, Pa (o,q,w,z,cc,dd)
Damascus Tube Co., Pa (ee)
Electronic Parts Mfg. Co., Inc., NJ (z,bb,cc,ee,ff)
Elmet Div., North American Phillips Co., Inc., Me (o,w,z,aa,bb,cc,dd,ff)
Esco Corp., Ore
Fansteel Metallurgical Corp., Ill (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff) — Ad pp 161-164
Firth Sterling, Inc., Pa (q)
General Electric Co., Lamp Metals & Components Dept., Ohio (o,q,w,aa,bb, cc,dd,ff)
Hamilton Watch Co., Precision Metals Div., Pa (v,dd,ff)
Hardy, Charles, Inc., NY (aa)
Harvey Aluminum, Calif (o,bb)
Hayden Wire Works, Inc., Mass (aa,ff)
Johnston & Funk Titanium Corp., Ohio (bb,ff)
Kassel Export Co., Inc., NJ (v,bb,dd, ee,ff)
Linde Co., Div. of Union Carbide Corp., NY
Mallory, P.R. & Co., Inc., Ind (aa, bb)
Metal & Thermit Corp., NJ (w)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metco, Inc., NY (ff)
Metals and Residues, Inc., NJ (aa)
Molybdenum Corp. of America, Pa (o,w,z,aa,bb,cc,dd)
National-Standard Co., Mich (ff)
North American Phillips Co., Inc., Me (aa)
Nuclear Metals, Inc., Mass (w,ee)
Oregon Metallurgical Corp., Ore (w)
Plasmadyne Corp., Calif (aa)
Reduction & Refining Co., NJ (q,w,aa, bb,ff)
Schwarzkopf Development Corp., NY (aa,bb,cc,dd,ee,ff)
Shieldalloy Corp., NJ (aa)
Stauffer Chemical Co., NY (q)
Sylvania Electric Products, Inc., Chemical & Metallurgical Div., Pa (n,w,aa,bb,ff)
Temescal Metallurgical Corp., Calif (o,q,w,z)—Ad p 167
Tube Distributors Co., Inc., NY (ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Universal-Cyclops Steel Corp., Pa (o,q, z,cc)
Utica General Jobbing Foundry, Inc., NY (aa)
Vacuum Technology, Inc., Calif (cc,dd)
Wah Chang Corp., NY (n,aa,bb,ff)—Ad p 152
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb, cc,dd,ee)
Wolverine Tube Div., Calumet & Hecla Inc., Mich (ee)

Monel

(see Nickel)

Neoprene

(see Chloroprene Rubber)

Nickel and Its Alloys

Advance Stamping Co., Mich (dd)
Allied Research Products, Inc., Md (n)
Alloy Metal Powders, Inc., NY (aa)
Alloy Metal Products, Inc., Iowa (o, w)
Amalgamated Steel Corp., Ohio (o,bb)
American Metal Climax, Inc., NY (aa)
American Nickel Alloy Mfg. Corp.,NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
American Silver Co., NY (v,dd,ee,ff)
American Smelting & Refining Co., NY (n,w)
Arcos Corp., Pa (ff)
Auld, D.L. Co., Ohio (n)
Austenal Co., Div. of Howe Sound Co., NY (w)
Barrett Chemical Products Co., Inc., Conn (n)
Bart Mfg. Corp., NJ (aa)
Belmont Smelting & Refining Works, Inc., NY (n,o,w,aa)
Biddle Screw Products Co., Ind (o, bb,ee)
Bishop, J. & Co. Platinum Works, Pa (ee,ff)
Bridgeport Brass Co., Conn (bb,cc,dd, ee,ff)
Brinkerhoff Brass & Bronze Works, Inc., NY (cc,dd)
Brush Beryllium Co., Ohio (w)
Cannon-Muskegon Corp., Mich (o,v,w, cc,dd,ff)
Carpenter Steel Co., Webb Wire Div., NJ (ff)
Central Fabricators, Inc., Ohio (z, bb,cc,ee)
Chase Brass & Copper Co., Inc., Sub. of Kennecott Copper Corp., Conn (o,z,bb,cc,ee,ff)
Chicago Steel Service Co., Ill (o,q,z, bb,cc,dd,ee,ff)
Chromium Corp. of America, NY (v)
Coast Metals, NJ (aa,bb)
Craft Metal Spinning Co., Ill (cc)
Crucible Steel Co. of America, Pa (o,q,v,z,bb,cc,dd,ee,ff)
Damascus Tube Co., Pa (ee)
Designers Metal Corp., Ill (cc)
Dixon Sintaloy, Inc., Conn (o)
Dormont Mfg. Co., Pa (ee)
Driver, Wilbur B. Co., NJ (v,bb,dd,ff)
Driver-Harris Co., NJ (v,bb,dd,ff)
Electronic Parts Mfg. Co., Inc., NJ (bb,dd,ee,ff)
Elgin National Watch Co., Abrasives Div., Ill (o,bb,dd,ff)
Erskine Precision Wire Corp., Pa (ff)
Federated Metals Div., American Smelting & Refining Co., NY (n)
Foote Mineral Co., Pa (w,aa)
Fox Products Co., Pa (n)
Fromson Orban Co., Inc., NY (ee)
General Electric Co., Metallurgical Products Dept., Mich (q,w,aa,bb,cc, dd)
General Motors Corp., Central Foundry Div., Mich
General Plate Div., Metals & Controls Corp., Mass (v,cc,dd)
Gibson Electric Sales Corp., Pa (bb, dd,ff)

KEY

MATERIALS

a—Aluminum and its alloys	e—Magnesium and its alloys	j—Zinc and its alloys
b—Copper and its alloys	f—Nickel and its alloys	k—Thermoplastics
c—Iron and its alloys (except steel)	g—Steels	l—Thermosetting plastics
d—Lead and its alloys	h—Titanium and its alloys	m—Elastomers

BASIC FORMS

n—Anodes	r—Custom formed parts (incl. specialties)	v—Foil	aa—Powder
o—Bar	s—Fibers	w—Ingot	bb—Rod
p—Base resins, polymers or gums	t—Film	x—Laminating, casting resins	cc—Sheet
q—Billets	u—Foams (component materials or products)	y—Molding compounds	dd—Strip
		z—Plate	ee—Tubing
			ff—Wire

Glidden Co., Chemical Divs., Metals Dept., Ind (aa)
Metals Dept., Pa (aa)
Grand Rapids Brass Co., Mich (z)
Hamilton Watch Co., Precision Metals Div., Pa (v,w,bb,dd)
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (aa,ff)
Haynes Stellite Co., Div. of Union Carbide Corp., NY (o,q,v,w,z,aa,bb) cc,dd,ee,ff)
Hettleman, K. & Sons, Inc., Mo (w)
Horton-Angell Co., Mass (n,o,bb,cc, ee,ff)

Hoskins Mfg. Co., Mich
(bb,dd,ff)—Ad p 148

Huntington Alloy Products Div., International Nickel Co., Inc., W.Va (z,bb,cc,dd,ee,ff)
Jelliff, C.O. Mfg. Corp., Conn (ff)
K. & L. Plating Co., Pa (z)
Kanthal Corp., Conn (bb,dd,ff)
Kelsey-Hayes Co., Mich (o,q,z,cc)
Kelsey-Hayes Co., Metals Div., NY (o,q,v,w,z,bb,cc,dd,ff)
Kinkead Industries, Inc., Ill (cc,dd)
Kwikset Powdered Metal Products, Calif (aa)
Lakeland Industries, Minn (z)
Lavin, R. & Sons, Inc., Ill (w)
Leach & Garner Co., Industrial Div., Mass (v,cc,dd,ee,ff)
McGean Chemical Co., Ohio (n,o,bb,dd)
Metal Forming Corp., Div. of Vanadium-Alloys Co., Ind (ee)
Metal Goods Corp., Mo (o,z,bb,cc,dd, ee,ff)
Metal Hydrides, Inc., Mass (aa)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metals Disintegrating Co., Inc., NJ (aa)
Metco, Inc., NY (ff)
Michigan Seamless Tube Co., Mich (ee)
Modern Plating Corp., Ill (n)
National Lead Co., NY (q,w)
National-Standard Co., Mich (ff)
National-U.S. Radiator Corp., Plastic Metals Div., NY (aa)
Nesor Alloy Products Co., NJ (ff)
New England Brass Co., Mass (cc,dd)
New Jersey Metals Co., NJ (n,q,w)
New Jersey Zinc Co., NY (aa)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Norwalk Powdered Metals, Inc., Conn (aa)
Nuclear Metals, Inc., Mass (w,bb,dd, ee)
Plasmadyne Corp., Calif (aa)
Precision Tube Co., Inc., Pa (ee)
Pyron Corp., NY (aa)
Rathbone Corp., Mass (o,bb)
Republic Steel Corp., Steel & Tubes Div., Ohio (ee)
Rigidized Metals Corp., NY (cc,dd)

Riverside-Alloy Metal Div., H.K. Porter Co., Inc., NJ
(bb,dd,ff)—Ad p 150

Rooney Metals, Inc., Mass (v,dd)
Rolock, Inc., Conn (ff)
Sandusky Foundry & Machine Co., Ohio (ee)
Sel-Rex Corp., NJ (n,aa)
Seymour Mfg. Co., Conn (n)
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio (ee)
Sherritt Gordon Mines, Ltd., Canada (w,aa)
Sherwatt Equipment & Mfg. Co., Inc., NY (ff)
Shieldalloy Corp., NJ (aa)
Sierra Metals Corp., Sub. of American-Marietta Co., Ill (w)

Somers Brass Co., Inc., Conn
(v,dd)—Ad p 158

Standard Metals Corp., Mass (ee)
Stevens, Frederic B., Inc., Mich (n)
Superior Steel Corp., Pa (dd)

Superior Tube Co., Pa
(ee)—Ad pp 424-425

Sylvania Electric Products, Inc., Parts Div., Pa (ff)
Techalloy Co., Inc., Pa (o,v,bb,cc,dd, ff)
Temescal Metallurgical Corp., Calif (o,q,w,z)
Trent Tube Co., Pa (ee)
Tube Distributors Co., Inc., NY (ee)
Tube Methods Inc., Pa (ee)
Tube Reducing Corp., NJ (ee)
Udylite Corp., Mich (n)
Ullmann, Inc., Wis (o,ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
United Wire & Supply Corp., RI (ff)
Universal-Cyclops Steel Corp., Pa (o, q,z,bb,cc,dd,ff)
Utica General Jobbing Foundry, Inc., NY (aa)
Utility Mfg. Co., Mass (bb)
Vanadium-Alloys Steel Co., Pa (aa,ee)
Waimet Alloys Co., Mich (w)
Wall Colmonoy Corp., Mich (aa,bb, cc,ff)
Wall Tube & Metal Products Co., Tenn (ee)
Wallingford Steel Co., Conn (dd,ee)
Waterbury Rolling Mills, Inc., Conn (dd)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc, dd,ee)
Whitehead Metal Products Co., Inc., NY (o,q,z,bb,cc,dd,ee,ff)
Wilson, H.A. Co., Div. of Engelhard Industries, Inc., NJ (bb,dd)
Wisconsin Centrifugal Foundry, Inc., Wis (ee)
Youngstown Welding & Engineering Co., Ohio (ee)

Nickel Silver
(see Copper)

Nitrides
(see Refractories)

Nitrile Rubber
(see Acrylonitrile-Butadiene Rubber)

Nodular Iron
(see Iron)

Nylon
(see Polyamides)

Organic Coatings
(formulations — lacquers, enamels, etc; see also Precoated Metals)

Abalon Precision Mfg. Corp., NY
Acheson Colloids Co., Mich
Acme Plating Co., Ohio
Acme Stamping & Wire Forming Co., Pa
Alcylite Plastics & Chemical Corp., Calif
AllianceWall Div., AllianceWare, Inc., Ohio
Allied Chemical Corp., Plastics Div., NY
Allied Research Products Inc., Md
Alpha-Molykote Corp., Conn
Aluminum Co. of America, Pa
Amercoat Corp., Calif
American Cyanamid Co., Plastics & Resins Div., NY
American Solder & Flux Co., Pa
American-Marietta Co., Ill
Armitage, J.L. & Co., NJ
Ashtabula Mfg. Co., Ohio
Atlas Mineral Products Co., Pa
Auld, D.L. Co., Ohio
Automotive Rubber Co., Inc., Mich
Avondale Co., Ill
B.B. Chemical Co., Bostik Dept., Mass.
Babbitt Chemical Co., Inc., Mass
Barrett Varnish Co., Ill
Bee Chemical Co., Ill
Berry Bros., Mich
Bloggs, Carl H. Co., Inc., Calif
Bisonite Co., Inc., NY
Boatwright Paint & Varnish Works, Inc., Ga
Borden Chemical Div., Borden Co., NY
Bradley Paint Co., Pa
Bradley & Vrooman Co., Ill
Burwood Products Co., Mich
Capitol Chemical Co., Ill
Carboline Co., Mo
Cellcote Co., Ohio

Cellusuede Products, Inc., Ill
(flock)—Ad p 348

Chemical Coatings Corp., Conn
Chemical Coatings & Engineering Co., Inc., Pa
Chemical Development Corp., Mass
Chemical Process Co., Calif

Chemical Products Corp., RI
—Ad p 352

Chemo Products, Inc., RI
Clinton Co., Ill
Columbia Technical Corp., NY
Commercial Chemical Co., Ohio
Co-Polymer Chemicals Inc., Mich
Cordo Chemical Corp., Conn
Cosden Paint Co., NJ
Davis Products Corp., NY
Day, James B. & Co., Ill
Dayton Rubber Co., Ohio
Debevoise Co., NY
Dennis Chemical Co., Mo
Designers Metal Corp., Ill
De Soto Chemical Coatings, Inc., Ill
De Soto Paint & Varnish Co., Tex
Dewey & Almy Chemical Div., W. R. Grace & Co., Mass
Dirilyte Co. of America, Inc., Ind
Doehler-Jarvis Div., National Lead Co., Ohio
Dollin Corp., NJ
Douglas & Sturgess, Calif
du Pont de Nemours, E. I. & Co., Inc., Del
Duralac Chemical Corp., NJ
Dyna-Therm Chemical Corp., Calif
Earl Paint Corp., NY
Egan & Hausman Co., Inc., NY
Egyptian Lacquer Mfg. Co., NJ
Electro Chemical Engineering & Mfg. Co., Pa
Electrofilm, Inc., Calif
Electronic Production & Development, Inc., Chemical Div., Calif
Ellicott-Brandt, Inc., Md
Enamelstrip Corp., Sub. of National Steel Corp., Pa

Enthone, Inc., Conn
—Ad p 346

Everlite Corp., Wash
Felsenthal, G. & Sons, Ill
Fidelity Chemical Products Corp., NJ
Flexrock Co., Pa
Forbes Finishes Div., Pittsburgh Plate Glass Co., Ohio
Foss Mfg. Co., Id
Fox Co., Ohio
Furane Plastics Inc., Calif
G. S. Plastics Co., Ohio
Gates Engineering Co., Del
General Electric Co., Chemical Materials Dept., Mass
General Plastics Corp., NJ
General Plastics Mfg. Co., Wash
Globe Paint Works, Inc., Pa
Goodyear Tire & Rubber Co., Chemical Div., Ohio
Graphite Products Corp., Ohio
Grand Rapids Varnish Corp., Mich
Grems Mfg. Co., Ore
Hamilton Die Cast, Inc., Ohio
Hardman, H.V. Co., Inc., NJ
Hauger-Beegle Assoc., Inc., Ill
Haveg Industries, Inc., Del
Hilo Varnish Corp., Industrial Finishes Div., Mass
Horn, A. C. Cos., NJ
Hughson Chemical Co., Div. of Lord Mfg. Co., Pa
Hysol Corp., NY
Industrial Metal Protectives Inc., Ohio
Industrial Paint Div., Glidden Co., Ohio
Industrial Polychemical Service, Calif
Interchemical Corp., Finishes Div., NJ
Jamestown Finishes, NY
Jasper Lacquer Co., Inc., Ind
Jema-American, Inc., NJ
Jervis Corp., Mich
Johnson, S.C. & Son, Inc., Wis
Jones-Dabney Co., Div. of Devoe & Raynolds Co., Inc., Ky
Keystone Refining Co., Inc., Pa
Kish Industries, Inc., Mich
Knight, Maurice A. Co., Ohio
Lacquer & Chemical Corp., NY
Lacquer Products, Inc., Ohio
Lakewood Metal Products, Inc., Conn
Landau, J. & Co., Inc., NJ
Lithcote Corp., Ill
Lowe Bros. Co., Ohio
Maas & Waldstein Co., NJ
Magic Chemical Co., Mass
Marblette Corp., NY
McDougall Butler Co., Inc., NY
McGee Chemical Co., Inc., Pa
Mearl Corp., NY
Merix Chemical Co., Ill

Metal & Thermit Corp., NJ
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Metals Engineering Corp., Tenn
Micarta Div., Westinghouse Electric Corp., SC
Michigan Chrome & Chemical Co., Mich
Midland Industrial Finishes Co., Ill
Minnesota Paints, Inc., Minn
Mirro Aluminum Co., Wis
Mobay Chemical Co., Pa
Mobile Paint Mfg. Co., Inc., Ala
Modern Plating Corp., Ill
Mono-Seal Products, Mass
Monsanto Chemical Co., Organic Chemicals Div., Mo
Munray Products Div., Fanner Mfg. Co., Ohio
Narmco Industries, Inc., Narmco Materials Div., Calif
National Mfg. Corp., NY
Naugatuck Chemical Div., U.S. Rubber Co., Conn
Navan Products, Inc., Sub. of North American Aviation, Inc., Calif
New Jersey Zinc Co., NY
Nikolas, G.J. & Co., Inc., Ill
Nukem Products Corp., NY
Octagon Process, Inc., NY
Owens-Illinois Glass Co., Closure & Plastics Div., Ohio
Paramount Paint & Lacquer Co., Calif
Parker Paint Mfg. Corp., Ind
Pecora, Inc., Pa
Penn Metal Co., Inc., W.Va
Permaspray Mfg. Co., Tex
Perry-Austen Mfg. Co., NY
Peterson, D.J. Co., Wis
Philadelphia Enameling Works, Inc., Pa
Pierce, F.O. Co., NY
Pierce & Stevens Chemical Corp., NY
Pittsburgh Plate Glass Co., Pa
Pittsburgh Steel Co., Pa
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif
Plume & Atwood Mfg. Co., Conn
Polymer Industries Inc., Conn
Powell Pressed Steel Co., Ohio
Pratt & Lambert, Inc., NY
Protective Treatments, Inc., Ohio
Queen Products Co., Inc., Ky
Quelcor, Inc., Pa
Radiant Color Co., Calif
Radiation Applications, Inc., NY
Raffi and Swanson, Inc., Mass
Randolph Products Co., NJ
Raybestos-Manhattan, Inc., NJ
Raybestos-Manhattan, Inc., Adhesives Div., Conn
Reynolds Aluminum Supply Co., Ga
Reynolds Chemical Products Co., Mich
Riegel Paper Corp., NY
Rinshed-Mason Co., Mich
Rodney Metals, Inc., Mass
Rosco Laboratories, NY
Royston Laboratories, Inc., Pa
Rubber Corp. of America, NY
Rustproofing & Metal Finishing Corp., Mass
Rust-Oleum Corp., Ill
Sanford Process Co., Inc., Calif
Saran Protective Coatings Co., Mich
Sauereisen Cements Co., Pa
Schori Process Div., Ferro-co Corp., NY
Schwartz Chemical Co., Inc., NY
Seal-Peel, Inc., Mich

Sealube Co., Mass
Seaporcel Metals, Inc., NY
Shasta Mfg. Co., Ohio
Sherwin-Williams Co., Ohio
Sierra Engineering Co., Calif
Simonsen Metal Products Co., Ill
Spraylat Corp., NY
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Stanley Chemical Co., Conn
Steel Protection & Chemical Co., Ind
Steelcote Mfg. Co., Mo
Subox, Inc., NJ
Sun Steel Co., Ill
Superior Plastics, Inc., Ill
Switzer Bros., Inc., Ohio
Tempil Corp., NY
Textileather Div., General Tire & Rubber Co., Ohio
Thompson and Co., Pa
Tousey Varnish Co., Ill
Tubular Rivet & Stud Co., Mass
Tuff Clad, Inc., Ohio
Union Chemical Corp., NJ
Union Paste Co., Mass
United Shoe Machinery Corp., Mass
U. S. Rubber Co., Ind
U.S. Stoneware Co., Ohio
Waterbury Cos., Inc., Conn
Watson-Standard Co., Pa
Wesber Stamping Corp., Wis
Western Coating Co., Mich
Westinghouse Electric Corp., Pa
Whirlclad Div., Polymer Corp., Pa
Worth Co., Wis
Wyandotte Chemicals Corp., Mich
Xylos Rubber Div., Firestone Tire & Rubber Corp., Ohio
Zeller Corp., Ohio
Zolatone Process, Inc., Calif
Zophar Mills, Inc., NY

Organic Coatings

(coaters)

Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich
Aldan Rubber Co., Pa
Alloy Products Corp., Wis
Aluminum Co. of America, Pa
Aluminum Specialty Co., Wis
American Emblem Co., Inc., NY
American Hard Rubber Co., Div. of Amerace Corp., NJ
Arbonite Corp., Pa
Ashtabula Mfg. Co., Ohio
Atlas Mineral Products Co., Pa
Auld, D.L. Co., Ohio
Automotive Rubber Co., Inc., Mich
Avondale Co., Ill
Bee Chemical Co., Ill
Biggs, Carl H. Co., Inc., Calif
Bishopric Products Co., Ohio
Bisonite Co., Inc., NY
Boatwright Paint & Varnish Works, Inc., Ga
Bradley Paint Co., Pa
Bradley & Vrooman Co., Ill
Capitol Chemical Co., Ill
Caspers Tin Plate Co., Ill
Chemical Coatings & Engineering Co., Inc., Pa
Chemical Development Corp., Mass
Chemo Products, Inc., RI
Cleveland Metal Products Co., Ohio
Coated Coil Corp., NY
Cohan Epner Co., Inc., NY
Colonial Alloys Co., Pa
Columbia Technical Corp., NY
Cordo Chemical Corp., Conn
Croname, Inc., Ill
Day, James B. & Co., Ill
Debevoise Co., NY
Dirilyte Co. of America, Inc., Ind
Dolin Metal Products, Inc., NY
Dollin Corp., NJ
Douglas & Sturgess, Calif
Duracote Corp., Ohio
Dyna-Therm Chemical Corp., Calif
Earl Paint Corp., NY
Electro Chemical Engineering & Mfg. Co., Pa
Electro Technical Div., Sun Chemical Corp., NJ
Electrofilm, Inc., Calif
Ellicott-Brandt, Inc., Md
Emerson & Cuming, Inc., Mass
Enamelstrip Corp., Sub. of National Steel Corp., Pa
Everlite Corp., Wash
Eyelet Specialty Div., International Silver Co., Conn
Falstrom Co., NJ
Farwell Metal Fabricating, Minn
Felsenthal, G. & Sons, Ill
Fletcher Enamel Co., W.Va
Forbes Finishes Div., Pittsburgh Plate Glass Co., Ohio
Foss Mfg. Co., Id
Fuller, H.B. Co., Minn
G. S. Plastics Co., Ohio
Gates Engineering Co., Del
General Plastics Corp., NJ
Globe Paint Works, Inc., Pa
Gomar Mfg. Co., Inc., NJ
Goodrich, B.F. Industrial Products Co., Ohio
Grand Rapids Brass Co., Mich
Grand Rapids Varnish Corp., Mich
H & R Plastics Industries, Inc., Pa
Hartglas Co., Ohio
Hauger-Beegle Assoc., Inc., Ill
Haveg Industries, Inc., Del
Hayden Wire Works, Inc., Mass
Hilo Varnish Corp., Industrial Finishes Div., Mass
Industrial Metal Protectives, Inc., Ohio
Industrial Paint Div., Glidden Co., Ohio
Jamison Plastic Corp., NY
Jervis Corp., Mich
Johnson, S.C & Son, Inc., Wis
Kelley Mfg. Co., Tex
Kickhaefer Mfg. Co., Wis
King, Alfred B., Co., Conn
Lakewood Metal Products, Inc., Conn
Lacquer & Chemical Corp., NY
Lithcote Corp., Ill
Lowe Bros. Co., Ohio
Ludlow Plastics, Mass
Luzerne Rubber Co., NJ
Maas & Waldstein Co., NJ
Magic Chemical Co., Mass
Merix Chemical Co., Ill
Metal-Cladding, Inc., NY
Metalweld, Inc., Protective Coating Div., Pa
Met-L-Wood Corp., Ill
Michigan Chrome & Chemical Co., Mich
Miller-Stephenson Chemical Co., Inc., Conn
Minnesota Mining & Mfg. Co., Adhesives, Coatings & Sealers Div., Mich
Mirra Cote Co., Inc., Calif
Modern Plating Corp., Ill
Mono-Seal Products, Mass
Morton Mfg. Co., Ill
Munray Products Div., Fanner Mfg. Co., Ohio
Montague Machine Co., Mass
Narmco Industries, Inc., Narmco Materials Div., Calif
National Glaco Chemical Corp., Industrial Coatings Div., Ill
National Lock Co., Ill
National Metal Products Co., Pa
Nikolas, G.J. & Co., Inc., Ill
Norgren-Stemac, Inc., Colo
Pecora, Inc., Pa
Peterson, D.J. Co., Wis
Polacoat, Inc., Ohio
Quelcor, Inc., Pa
Radiant Color Co., Calif
Radiation Applications, Inc., NY
Raffi and Swanson, Inc., Mass
Reed & Prince Mfg. Co., Mass
Respro Div., General Tire & Rubber Co., RI
Riegel Paper Corp., NY
Royston Laboratories, Inc., Pa
Rust-Oleum Corp., Ill
Rustproofing & Metal Finishing Corp., Mass
Schori Process Div., Ferro-co Corp., NY
Schwartz Chemical Co., Inc., NY
Smith-Victor Corp., Ind
Smoot-Holman Co., Calif
Steelcote Mfg. Co., Mo
Steere Enterprises, Inc., Ohio
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Stirrup Metal Products Corp., NJ
Sun Steel Co., Ill
Superior Plastics, Inc., Ill
Superior Plating, Inc., Minn
Tempil Corp., NY
Textileather Div., General Tire & Rubber Co., Ohio
Toyad Corp., Pa
Tuff Clad, Inc., Ohio
Union Chemical Corp., NJ
U.S. Rubber Co., Ind
U.S. Stoneware Co., Ohio
United-Carr Fastener Corp., Mass
Wayne Chemical Products Co., Mich
Whirlclad Div., Polymer Corp., Pa
Woodstock Div., Electric Auto-Lite Co., Ill
Worth Co., Wis
Zolatone Process, Inc., Calif

Organic Coatings —Claddings

(see also Laminates, Metal-Organic)

American Hard Rubber Co., Div. of Amerace Corp., NJ
Arvin Industries, Inc., Ind
Automotive Rubber Co., Inc., Mich
Chemical Products Corp., RI
Electro Chemical Engineering & Mfg. Co., Pa
Lithcote Corp., Ill
Metal-Cladding, Inc., NY
Nukem Products Corp., NY
O'Sullivan Rubber Corp., Plastics Div., Va
Penn Metal Co., Inc., W.Va
Quelcor, Inc., Pa
Radiation Applications, Inc., NY
Seiberling Rubber Co., Plastics Div., Ohio
Shasta Mfg. Co., Ohio
Simoniz Products Div., Simoniz Co., Ill
Sun Steel Co., Ill
Tuff Clad, Inc., Ohio
Watson-Standard Co., Pa
Whirlclad Div., Polymer Corp., Pa

Organic Coatings —Prepainted Metals

Abalon Precision Mfg. Corp., NY
Aluminum Co. of America, Pa
Bridgeport Brass Co., Conn
Caspers Tin Plate Co., Ill
Coated Coil Corp., NY
Cooley, W.J. & Co., Tenn
Dow Chemical Co., Mich
Enamelstrip Corp., Sub. of National Steel Corp., Pa
Fairmont Aluminum Co., W.Va
Falstrom Co., NJ
Fryling Mfg. Co., Pa
Hauger-Beegle Assoc., Inc., Ill
Hoofer Mfg. Co., Ill
Kaiser Aluminum & Chemical Sales Inc., Ill
Kees, F.D. Mfg. Co., Neb
Kinkead Industries, Inc., Ill
Lundquist Tool & Mfg. Co., Inc., Mass
Mahon, R.C. Co., Mich
National Metal Products Co., Pa
Penn Metal Co., Inc., W.Va
Philadelphia Steel & Wire Corp., Pa
Pittsburgh Steel Co., Pa
Republic Steel Corp., Ohio
Reynolds Aluminum Supply Co., Ga
Reynolds Metals Co., Va
Rigidized Metals Corp., NY
Rodney Metals, Inc., Mass
Roll Coater, Inc., Ind
Security Sash & Screen Co., Mich
Sharon Steel Corp., Pa
Sillcocks Miller Co., NJ
Simoniz Products Div., Simoniz Co., Ill
Stainless and Strip Div., Jones & Laughlin Steel Corp., Ohio
Sun Steel Co., Ill
Thomas Strip Div., Pittsburgh Steel Co., Pa

Organic Coatings, Strippable

Adhesive Products Corp., NY
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich
Amercoat Corp., Calif
American Latex Products Corp., Calif
Angier Adhesives Div., Interchemical Corp., Mass
Atlas Mineral Products Co., Pa
Avondale Co., Ill
Babbitt Chemical Co., Inc., Mass
Bee Chemical Co., Ill
Belding Corticelli Industries, NY
Better Finishes & Coatings, Inc., NJ
Bischoff Chemical Corp., NY
Bisonite Co., Inc., NY
Blaco Mfg. Co., Ohio
Borden Chemical Div., Borden Co., NY
Bradley & Vrooman Co., Ill
Carboline Co., Mo
Chemical Coatings & Engineering Co., Inc., Pa
Chemical Development Corp., Mass
Chemical Products Corp., RI
Cosden Paint Co., NJ

KEY

MATERIALS

a—Aluminum and its alloys	e—Magnesium and its alloys	j—Zinc and its alloys
b—Copper and its alloys	f—Nickel and its alloys	k—Thermoplastics
c—Iron and its alloys (except steel)	g—Steels	l—Thermosetting plastics
d—Lead and its alloys	h—Titanium and its alloys	m—Elastomers

BASIC FORMS

n—Anodes	r—Custom formed parts (incl. specialties)	v—Foil	aa—Powder
o—Bar	s—Fibers	w—Ingot	bb—Rod
p—Base resins, polymers or gums	t—Film	x—Laminating, casting resins	cc—Sheet
	u—Foams (component materials or products)	y—Molding compounds	dd—Strip
q—Billets		z—Plate	ee—Tubing
			ff—Wire

Cycleweld Div., Chrysler Corp., Mich
De Soto Chemical Coatings, Inc., Ill
De Soto Paint & Varnish Co., Tex
Dennis Chemical Co., Mo
Dip Seal Plastics, Inc., Ill
Diversey Corp., Metal Industries Div., Ill
Dow Chemical Co., Plastics Div., Mich
du Pont de Nemours, E. I. & Co., Inc., Del
Earl Paint Corp., NY
Felsenthal, G. & Sons, Ill
Fidelity Chemical Products Corp., NJ
Fine Organics, Inc., NJ
Foss Mfg. Co., Id
Frost Paint & Oil Corp., Minn
G. S. Plastics Co., Ohio
George, P.D. Co., Mo
Globe Imperial Corp., Plastic-Seal Div., Ill
Houghton, E.F. & Co., Pa
Hughes Glue Co., Mich
Hughson Chemical Co., Div. of Lord Mfg. Co., Pa
Industrial Paint Div., Glidden Co., Ohio
Interchemical Corp., Finishes Div., NJ
Jamestown Finishes, NY
Johnson, S.C & Son, Inc., Wis
Kinkead Industries, Inc. Ill
Koster-Keunen Mfg. Co. Inc. NY
Lacquer & Chemical Corp., NY
Lacquer Products, Inc., Ohio
Landau, J. & Co., Inc., NJ
Ludlow Plastics, Mass
Maas & Waldstein Co., NJ
Magic Chemical Co., Mass
Metal & Thermit Corp., NJ
Micarta Div., Westinghouse Electric Corp., SC
Michelman Chemicals, Inc., Ohio
Midland Adhesive & Chemical Corp., Mich
Minnesota Mining & Mfg. Co., Adhesives, Coatings & Sealers Div., Mich
Minnesota Paints, Inc., Minn
Modern Plating Corp., Ill
Morningstar-Paisley, Inc., NY
Munray Products Div., Fanner Mfg. Co., Ohio
Nikolas, G.J. & Co., Inc., Ill
Nukem Products Corp., NY
Octagon Process, Inc., NY
Parker Paint Mfg. Corp., Ind
Pecora, Inc., Pa
Pennsalt Chemicals Corp., Pa
Pierce & Stevens Chemical Corp., NY
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif
Plume & Atwood Mfg. Co., Conn
Poly Resins, Calif
Polyken Div., Kendall Co., Ill
Polymer Chemical Co., Ohio
Polymer Industries, Inc., Conn
Protective Treatments, Inc., Ohio
Puritan Co., Inc., NY
Pyramid Plastics, Inc., Ill
Quelcor, Inc., Pa
Radiation Applications, Inc., NY
Reynolds Chemical Products Co., Mich
Schwartz Chemical Co., Inc., NY
Seal-Peel, Inc., Mich
Servwell Products Co., Ohio
Sherwin-Williams Co., Ohio
Sierra Engineering Co., Calif
Spraylat Corp., NY
—Ad p 355
Steere Enterprises, Inc., Ohio
—Ad p 351
Sun Steel Co., Ill
Thompson and Co., Pa
Turco Products, Inc., Calif
Union Chemical Corp., NJ
Union Paste Co., Mass
U.S. Rubber Co., Ind
U.S. Rubber Co., NY
U.S. Stoneware Co., Ohio
Valvoline Oil Co., Div. of Ashland Oil & Refining Co., Pa
Watson-Standard Co., Pa
Wayne Chemical Products Co., Mich
Western Coating Co., Mich
Whitfield Chemical Co., Mich
Xylos Rubber Co., Ohio
Zophar Mills, Inc., NY

Oxide Coatings

(see Conversion Coatings)

Oxides

(see Ceramics; Refractories)

Paints

(see Organic Coatings)

Papers

(cellulose, inorganic, synthetic; for industrial use)

Allied Chemical Corp., Plastics Div., NY
Auburn Mfg. Co., Conn
Avery Label Co., Calif
Consolidated Water Power & Paper Co., Wis
Dexter, C.H. & Sons, Inc., Conn
Filpaco Industries, Inc., Ill
Fox Edge Co., Inc., Mass
General Gasket, Inc., Conn
Georgia-Pacific Corp., Ore
Gomar Mfg. Co., Inc., NJ
Hexcel Products, Inc., Calif
Hollingsworth & Vose Co., Mass
Insulation Mfrs. Corp., Ill
Johns-Manville Corp., NY
Knowlton Bros., Inc., NY
—Ad p 312
Mica Fabricating Co., NJ
Mosinee Paper Mills Co., Wis
National Gasket & Washer Mfg. Co., Inc., NY
Nicolet Industries, Inc., NY
Owens-Illinois Glass Co., Paper Products Div., Ohio
Panelyte Div., St. Regis Paper Co., NJ
Plymouth Cordage Co., Mass
Precision Paper Tube Co., Ill
Raybestos-Manhattan, Inc., NJ
Riegel Paper Corp., NY
Rogers Corp., Conn
—Ad pp 270-271
Spaulding Fibre Co., Inc., NY
Spruce Pine Mica Co., Inc., NC
Standard Asbestos Mfg. Co., Ill
Standard Washer & Mat, Inc., Conn
Twitchell, E. W., Inc., Pa
Upson Co., NY
Vellumoid Co., Mass
Victor Mfg. & Gasket Co., Ill
West Virginia Pulp & Paper Co., NY
Wisconsin Gasket & Mfg. Co., Wis

Perforated Materials

Acme Precision Products, Inc., Ohio (a,b,g,h)
Aluminum Co. of America, Pa (a)
American Metal Products, Inc., Ohio (g)
American Nickel Alloy Mfg. Corp., NY (f)
Atlantic Steel Co., Ga (a,b,g)
BLC Porous Materials Co., Calif (a, b,e,f,g,j,k,l,m)
Biersach & Niedermeyer Co., Wis (a, b,c,f,g)
Bishop, J. & Co. Platinum Works, Pa
Blaco Mfg. Co., Ohio (b,g)
Bohn Aluminum & Brass Co., Mich (a)
Brockway Pressed Metals, Inc., Pa (b, c)
Burgess-Norton Mfg. Co., Ill (c)
California Perforated Screen Co., Calif (a,b,c,f,g,j)
Caspers Tin Plate Co., Ill (g)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (b)
Clark Perforating Co., Mich (a,b,c,d, f,g,j,k,l,m)
Clendenin Bros., Inc., Md (a,b)
Colonial Alloys Co., Pa (a)
Colorado Fuel & Iron Corp., Colo (g)
Diamond Mfg. Co., Pa (a,b,c,d,e,f,g,h, j)
Duplex Mfg. Corp., Ark (g)
Edgcomb Steel & Aluminum Corp., NJ (a,g)
Electro-Chemical Engineering Co., NY (a)
Ellwood City Iron & Wire Co., Pa (c)
Emerson-Sack-Warner Corp., Mass (a, b,f,g)
Erdle Perforating Co., Inc., NY (a, b,c,d,f,g,j,k,l)
Esco Corp., Ore (g)
Falstrom Co., NJ (a,b,e,g)
Fletcher Enamel Co., W.Va (a,b,c,d,e, f)
Fox Products Co., Pa (c)
General Alloys Co., Mass (a,b,f)
Greene, G.G. Corp., Pa (g)
Grigoleit Co., Ill (a,g)
Harrington & King Perforating Co., Inc., Ill (a,b,c,d,e,f,g,h,j,k,l,m)
Hawkridge Bros. Co., Mass (a)
Hendrick Mfg. Co., Pa (a,b,c,d,e,f,g,h, j)
Houston Blow Pipe & Sheet Metal Works, Tex (a,b,g)
Ideal Can Co., Mass (g)
Industrial & Furnace Car Div., Irwin-Sensenich Corp., Pa (a,g)
Kees, F.D. Mfg. Co., Neb (g)
Levinson Steel Co., Pa (g)
Madin Plastics, Inc., NJ (k)
Manganese Steel Forge Co., Pa (g)
McCarter Iron Works, Inc., Pa (g)
McNally Pittsburgh Mfg. Co., Kan (a, g)
Melco Wire Products, Calif (a)
Morton Mfg. Co., Ill (a,g)
Mundt, Charles & Sons, NJ (a,b,c,d, e,f,g,h,j,k,l,m)
National Galvanizing Co., Pa (g)
National Lead Construction Co., Inc., Pa (d)
National-Standard Co., Cross Perforated Metals Plant, Pa (a,g)
Norwalk Powdered Metals, Inc., Conn (b)
Parker Metal Goods Co., Mass (g)
Perforating Industries, Inc., NJ
(k,l)—Ad p 422
Republic Steel Corp., Ohio (g)
Reynolds Metals Co., Va (a)
Rigidized Metals Corp., NY (a,b,f, g,h,j)
Rockwell Engineering Co., Ill (a,b,c,g)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
Servwell Products Co., Ohio (b,g)
Sillcocks Miller Co., NJ (a,b)
Simoniz Products Div., Simoniz Co., Ill (a,g)
Stainless Metals, Inc., NY (g)
Standard Stamping & Perforating Co., Ill (a,b,g,k,l,m)
Thompson Pipe & Steel Co., Colo (g)
Toepfer & Sons., Inc., Wis (a,b,c,e,f, g,h,j)
Wesbar Stamping Corp., Wis (a)
Whitehead Metal Products Co., Inc., NY (a,b,f)
Whyte, Oliver Co., Inc., NY (a,g)
Wire & Iron Products, Inc., Mich (f, g)
Wrought Washer Mfg. Co., Wis (g)

Permanent Mold Castings

(see Castings)

Phenolics

Ace Plastic Co., NY (bb,cc,dd)
Adhesive Products Corp., NY (x)
Alcylite Plastics & Chemical Corp., Calif (p,x,y)
Allied Chemical Corp., Plastics Div., NY
(p,y)—Ad pp 257-260
American-Marietta Co., Adhesive, Resin & Chemical Div., Wash (p)
Anderson Assoc., Inc., Ohio (y)
Archer-Daniels-Midland Co., Minn (y)
Atlas Mineral Products Co., Pa (x)
Auburn Plastic Engineering, Ill (bb,cc)
Baer, N.S. Co., NJ (bb,cc,dd,ee)
Bisonite Co., Inc., NY (x)
Blank, Arthur & Co., Inc., Mass (cc)
Booty Resineers Div., American-Marietta Co., Ohio (p)
Borden Chemical Div., Borden Co., NY (p)
Cadillac Plastic & Chemical Co., Mich (bb,cc,dd,ee)
Calfibe Co., Inc., Calif (cc,ee)
Caradco Corp., Durel Div., Iowa (cc)
Catalin Corp. of America, NY (p,x)
Cleveland Container Co., Ohio (ee)
Coast Mfg. & Supply Co., Calif (y)
Colonial Kolonite Co., Ill (bb,cc,ee)
Comco Plastics, Inc., NY (bb,cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Cordo Chemical Corp., Conn (x,y)
CrystalX Corp., Pa (bb,cc,dd,ee)
Curbell, Inc., NY (bb,cc,dd,ee)
Delta Plastics Co., NJ (bb,cc,dd,ee)
Douglas & Sturgess, Calif (x,y)
Dunnican Assoc., NJ (p,y)
Durez Plastics Div., Hooker Chemical Corp., NY
(p,x,y)—Ad pp 262-263
Dyna-Therm Chemical Corp., Calif (p)
Electrofilm, Inc., Calif (t)
Eljay Corp., Md (bb,cc,dd,ee)
Fiber Glass Industries, Inc., NY (x,cc)
Fiberite Corp., Minn (y)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (p,x,y)
Formica Corp., Sub. of American Cyanamid Co., Ohio (bb,cc,dd,ee)
Foss Mfg. Co., Id (u,x)
Galigher Co., Utah (bb,cc,dd,ee)
General Electric Co., Chemical Materials Dept., Mass (p,x,y)
General Electric Co., Laminated Products Dept., Ohio (bb,cc,ee)
General Plastics Mfg. Co., Wash (bb, cc,dd,ee)
Grigoleit Co., Ill (p,s)
Haveg Industries, Inc., Del (p,bb,cc, ee)
Hercules Powder Co., Inc., Del (p)
Hiller Aircraft Corp., Adhesive Engineering Div., Calif (u)
Iten Fibre Co., Ohio (bb,cc,dd,ee)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Lewis, J.P. Co., Plastic Products Div., NY (cc)
Kish Industries, Inc., Mich (u,x)
Kurz Kasch, Inc., Ohio (y)
Laminated Plastex Corp., Ohio (x,cc)
Maloney, F.H. Co., Tex (x,y,bb,cc,dd, ee)
Marblette Corp., NY (p,u,x,y,bb,cc,ee)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (bb,cc,ee)
Micarta Div., Westinghouse Electric Corp., SC (p,x)
Monsanto Chemical Co., Plastics Div., Mass
(p,x)—Ad pp 212-213
Narmco Industries, Inc., Narmco Materials Div., Calif (u,x,y,dd)
National Moldite Co., NJ (y)
National Vulcanized Fibre Co., Del (bb,cc,dd,ee)
New England Laminates Co., Inc., Conn (cc)
Nopco Chemical Co., NJ (p)
Norrich Plastics Corp., NY (bb,cc,dd, ee)
Northern Plastics Corp., Wis (cc,dd)
Omni Products Corp., NY (y)
Panelyte Div., St. Regis Paper Co., NJ (x,bb,cc,dd,ee)
Penn Fibre & Specialty Co., Inc., Pa (bb,cc,dd,ee)
Permali, Inc., Pa (bb,cc,dd)
Philrus Products Co., NJ (bb,cc,dd,ee)
Plastics Engineering Co., Wis
(p,x,y,aa)—Ad p 222
Poly Resins, Calif (p,x)
Precision Paper Tube Co., Ill (ee)
Pyrosil Inc., Ohio (x,cc)

Raybestos Div., Raybestos-Manhattan, Inc., Conn (p,x)
Raybestos-Manhattan, Inc., Adhesives Div., Conn (p,x)
Raybestos - Manhattan, Inc., Reinforced Plastics Div., Pa
(p,x,y)—Ad p 216
Reichhold Chemicals, Inc., NY (p,x,y)
Rezolin, Inc., Calif (p,u,x)
Richardson Co., NY (bb,cc,ee)
Rogers Corp., Conn
(y)—Ad pp 270-271
Schenectady Varnish Co., Inc., NY (p, x)
Schwab Plastic Corp., Mich (bb,cc,dd, ee)
Sierra Electric Corp., Calif (y)
Spaulding Fibre Co., Inc., NY (bb, cc,dd,ee)
Spencer Rubber Co., Conn (u)
Stokes Molded Products Div., Electric Storage Battery Co., NJ
Strick Plastics Co., Pa (u,cc)
Sun Chemical Corp., Electro Technical Div., NJ (x)
Swedlow, Inc., Calif (cc)
Synco Resins, Inc., Conn (p,x)
Synthane Corp., Pa (bb,cc,dd,ee)
Taylor Fibre Co., Pa (bb,cc,dd,ee)
Texas Glass Fiber Corp., Tex (y)
Thombert, Inc., Iowa (bb,cc,dd,ee)
Union Carbide Plastics Co., Div. of Union Carbide Corp., NY
(p,u,x,y)—Ad p 261
U.S. Polymeric Chemicals, Inc., Conn (s,y)
Varcum Chemical Corp., NY (p)
Watertown Mfg. Co., Conn (p,y)
Western Backing Corp., Calif (y)
Westlake Plastics Co., Pa (bb,cc,dd,ee)
Wilmington Fibre Specialty Co., Del (bb,cc,ee)

Phosphate Coatings
(see Conversion Coatings)

Phosphor Bronze
(see Copper)

Pipe
(see Tubing)

Plaster Mold Castings
(see Castings)

Plastics
(see specific material and form)

Plate
(see specific metal)

Plated Coatings
(see Electroplated Coatings; Preplated Metals)

Platinum and Platinum Group Alloys
American Metal Climax, Inc., NY (aa)
American Platinum & Silver Div., Engelhard Industries, Inc., NY (n, v,z,aa,bb,cc,dd,ee,ff)
American Platinum Works, NJ (z)
American Silver Co., NY (v,dd,ee,ff)
Anaconda Co., NY (n,v,cc)
Baker & Co., Inc., NJ (n,o,v,w,z,aa, bb,cc,dd)
Bishop, J. & Co. Platinum Works, Pa (n,o,v,z,bb,cc,dd,ee,ff)
Deringer Metallurgical Corp., Ill (cc, dd,ee,ff)
Eastern Smelting & Refining Corp., Mass (n,o,v,w,z,aa,bb,cc,dd,ee,ff)
Electronic Parts Mfg. Co., Inc., NJ (ff)
Gibson Electric Sales Corp., Pa (bb, dd,ff)
Goldsmith Bros. Div., National Lead Co., Ill (n,o,v,w,z,bb,cc,dd,ff)
Hagstoz, T.B. & Son, Pa (n,cc,dd,ff)
Hamilton Watch Co., Precision Metals Div., Pa (ff)
Handy & Harman, NY (n,o,q,v,w,z,aa, bb,cc,dd,ee,ff)
Hanovia Chemical & Mfg. Co., NJ (aa)
Hardy, Charles, Inc., Mass (aa)
Hayden Wire Works, Inc., Mass (ff)
Hudsar, Inc., NJ (w)
International Nickel Co., Inc., Platinum Metals Div., NY
Leach & Garner Co., Industrial Div., Mass (n,o,v,bb,cc,dd,ee,ff)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,dd,ee,ff)
Metz Refining Co., NJ (n,o,q,z,aa,bb, cc,dd,ee,ff)
Nesor Alloy Products Co., NJ (dd,ff)
Ney, J.M. Co., Industrial Div., Conn (z,bb,cc,dd,ff)
Nuclear Metals, Inc., Mass (w)
Sel-Rex Corp., NJ (n,aa)
Standard Metals Corp., Mass (cc,dd,ff)
Texas Instruments, Inc., Metals & Controls Div., Mass (n,o,q,v,w,z,aa, bb,cc,dd,ee,ff)
Technic, Inc., RI (aa)
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif (aa,cc,dd,ff)
Wildberg Bros. Smelting & Refining Co., Calif (n,o,v,w,z,aa,bb,cc,dd,ff)
Williams Gold Refining Co., Inc., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Wilson H.A. Div., Engelhard Industries, Inc., NJ (ff)

Plywood
(see Wood)

Polyamides
(nylon)
Ace Plastics Co., NY (bb,dd)
Adhesive Products Corp., NY (x)
Allied Chemical Corp., Plastics Div., NY
(p,s,t,y)—Ad pp 257-260
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,dd,ee)
American Molding Powder & Chemical Co., NY (y)
Anchor Plastics Co., Inc., NY (bb,dd, ee)
Anderson Asso., Inc., Ohio (y)
Auburn Plastic Engineering, Ill (t,bb, cc,ee)
Bamberger, Claude P., Inc., NJ (y)
Belding Corticelli Industries, NY (p,x, y)
Cadillac Plastic & Chemical Co., Mich (t,bb,cc,dd,ee)
Catalin Corp. of America, NY (y)
Chemical Coatings & Engineering Co., Inc., Pa (x)
Chippewa Plastics Co., Wis (t)
Colonial Kolonite Co., Ill (bb,cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd)
Conneaut Rubber and Plastics Co., Div. of U.S. Stoneware Co., Ohio (bb,ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Danielson Mfg. Co., Conn (bb,cc,dd,ee)
du Pont de Nemours, E. I. & Co., Inc., Del (p,s,y)
Dyna-Therm Chemical Corp., Calif (p)
Emerson & Cuming, Inc., Mass (p,u,x)
Fiberfil, Inc., Ind (y)
Firestone Plastics Co., Pa (s)
Flexible Tubing Corp., Conn (ee)
Fluoro-Plastics, Inc., Div. of Flexrock Co., Pa (bb,cc)
Foster Grant Co., Mass (p,t,y,ee)
Fox Edge Co., Inc., Mass (s)
Fry Plastics International, Calif (bb, cc)
General Mills Inc., Chemical Div., Ill (p)
General Plastics Corp., NJ (t,x)
General Plastics Mfg. Co., Wash (bb, cc,dd,ee)
Glass Laboratories, NY (bb,dd,ee)
H & R Plastics Industries, Inc., Pa (t,bb,cc,dd,ee)
Hall Mfg. Corp., NJ (dd,ee)
Hauger-Beegle Asso., Inc., Ill (t)
Hyde Co., A.L., NJ
(bb,cc)—Ad p 408
Industrial Rayon Corp., NY (s)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Ludlow Corp., Mass (t)
Lus-Trus Corp., Mich (ce,ee)
Moore, Samuel & Co., Ohio (ee)
Muehlstein, H. & Co., Inc., NY (y)
Narmco Industries, Inc., Narmco Materials Div., Calif (x,y)
National Vulcanized Fibre Co., Del (bb,dd,ee)
Plast-Ad Mfg. Co., Ind (bb,cc,dd,ee)
Polymer Corp., Pa (y)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa
(t,bb,cc,dd,ee)—Ad p 264
Prince Rubber & Plastics Co., Inc., NY (bb,ee)
Raybestos - Manhattan, Inc., Plastic Products Div., Pa (x)
Reichhold Chemicals, Inc., NY (p)
Schwab Plastic Corp., Mich (bb,cc,dd, ee)
Shamban, W.S. & Co., Calif (t,bb,cc, dd,ee)
Southern Plastics Co., SC (bb,cc,dd, ee)
Spencer Chemical Co., Mo (p,x,y)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Thombert, Inc., Iowa (bb,cc,dd,ee)
U. S. Gasket Plastics Div., Garlock Packing Co., NJ (t,bb,cc,dd,ee)
Vulcan Div., Reeves Bros., Inc., NY (bb,dd,ee)
Western Plastics Corp., Neb (bb,dd,ee)
Westlake Plastics Co., Pa (t,bb,cc,dd, ee)

Polycarbonate Plastics
Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)
Fiberfil, Inc., Ind (y)
General Electric Co., NY (p,y)
General Electric Co., Chemical Materials Dept., Mass
(p,y)—Ad p 272
Glass Laboratories Inc., NY (bb,dd,ee)
Hall Mfg. Corp., NJ (dd,ee)
Hyde, A. L. Co., NJ
(bb,cc)—Ad p 408
Mobay Chemical Co., Pa (p,t,y)
Nixon-Baldwin Chemicals, Inc., NJ (cc)
Pennsylvania Fluorocarbon Co., Inc., Pa (ee)
Pittsburgh Plate Glass Co., Chemical Div., Pa (p,y)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa
(bb,cc,dd,ee)—Ad p 264
Southern Plastics Co., SC (bb,cc,dd,ee)
Visking Co., Div. of Union Carbide Corp., Ill (t)

Polyesters
Adhesive Products Corp., NY (x)
Alcylite Plastics & Chemical Corp., Calif (p)
Allied Chemical Corp., Plastics Div., NY
(p,y)—Ad pp 257-260
Alsynite Div., Reichhold Chemicals, Inc., Calif (cc)
American Cyanamid Co., Plastics & Resins Div., NY (x)
American Metaseal Corp., NJ (p)
American Petrochemical Corp., Mol-Rez Div., Minn (p,u,x)
American Products Mfg. Co., Inc., La (p)
Archer-Daniels-Midland Co., Minn (p)
Argo Plastic Products Co., Ohio (cc, ee)
Atlas Chemical Industries, Inc., Del (p,x)
Atlas Mineral Products Co., Pa (x)
Auburn Plastic Engineering, Ill (t,bb, cc,ee)
Avery Label Co., Calif (t)
Boonton Molding Co., NJ (x)
Brown Rubber Co., Inc., Ind (u)
Burkart, F. Mfg. Co., Div. of Textron Inc., Mo (u)
Cadillac Plastic & Chemical Co., Mich (t,x,cc)
Calfibe Co., Inc., Calif (cc,ee)
Cast Optics Corp., NJ (cc)
Celanese Polymer Co. Div., Celanese Corp. of America, NJ
(p)—Ad pp 224-225
Chemical Coatings & Engineering Co., Inc., Pa (p)
Chemical Process Co., Calif (p,x,y)
Coating Products, Inc., NJ (t,cc)
Colonial Kolonite Co., Ill (cc)
Columbia - Geneva Steel Div., U.S. Steel Corp., Calif (ee)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Cordo Chemical Corp., Conn (x,y)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (t)

KEY

MATERIALS

- a—Aluminum and its alloys
- b—Copper and its alloys
- c—Iron and its alloys (except steel)
- d—Lead and its alloys
- e—Magnesium and its alloys
- f—Nickel and its alloys
- g—Steels
- h—Titanium and its alloys
- j—Zinc and its alloys
- k—Thermoplastics
- l—Thermosetting plastics
- m—Elastomers

BASIC FORMS

- n—Anodes
- o—Bar
- p—Base resins, polymers or gums
- q—Billets
- r—Custom formed parts (incl. specialties)
- s—Fibers
- t—Film
- u—Foams (component materials or products)
- v—Foil
- w—Ingot
- x—Laminating, casting resins
- y—Molding compounds
- z—Plate
- aa—Powder
- bb—Rod
- cc—Sheet
- dd—Strip
- ee—Tubing
- ff—Wire

Dayton Rubber Co., Ohio (x,y)
De Soto Chemical Coatings, Inc., Ill (p,x,y)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Douglas & Sturgess, Calif (x,y)
du Pont de Nemours, E. I. & Co., Inc., Del (s,t)

Durez Plastics Div., Hooker Chemical Corp., NY
(p,y)—Ad pp 262-263

Eastman Chemical Products, Inc., Sub. of Eastman Kodak Co., NY (p)
Everlite Corp., Wash (cc)
Fiber Glass Industries, Inc., NY (x,y, cc)
Fiberglass Ohio Inc., Ohio (cc)
Flexfirm Products, Calif (s,y)
Flexible Tubing Corp., Conn (ee)
Foam Products, Inc., Pa (u)
Foamade Industries, Mich (u)
Foss Mfg. Co., Id (x)
Freeman Chemical Corp., Wis (p,x)
Fry Plastics International, Calif (p,x)
Galigher Co., Utah (p,s,x)
General Electric Co., NY (x)
General Tire & Rubber Co., Chemical Div., Ohio (p)
Gering Plastics Div., Studebaker-Packard Corp., NJ (y)
Glass Reinforced Plastics Corp., Ohio (bb,ee)
Glastic Corp., Ohio (y,bb,cc,)
Goodrich, B.F. Co., Sponge Products Div., Conn (u)
Goodyear Tire & Rubber Co., Chemical Div., Ohio (p)
Hall, C.P. Co., Ohio (p)
Haskelite Mfg. Div., Evans Products Co., Mich (cc)
Hastings & Co., Inc., Pa (t)
Haveg Industries, Inc., Del (cc)
Hays Mfg. Co., Pa (y,cc)

Industrial Paint Div., Glidden Co., Ohio
(p,x)—Ad p 273

Insulation Mfrs. Corp., Ill (cc,dd)
Interchemical Corp., NY (p,x,y)
Interchemical Corp., Finishes Div., NJ (p,x)
Johns-Manville Corp., NY (cc)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Kish Industries, Inc., Mich (x)
Knight, Maurice A. Co., Ohio (ee)
Laminated Plastex Corp., Ohio (x,cc)
Lewis, G.B. Co., Wis (bb)
Luminous Resins, Inc., Ill (y)
Maloney, F.H. Co., Tex (x,y)
Micarta Div., Westinghouse Electric Corp., SC (p,y)
Minnesota Mining & Mfg. Co., Minn (s)
Mobay Chemical Co., Mo (p)
Muehlstein, H. & Co., Inc., NY (p)
Narmco Industries, Inc., Narmco Materials Div., Calif (x,y,dd)
National Vulcanized Fibre Co., Del (cc,dd)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,u,x,y)
Nopco Chemical Co., NJ (p)
Omni Products Corp., NY (p)
Ormond Mfg. Co., Inc., NJ (cc,dd)
Panelyte Div., St. Regis Paper Co., NJ (x,y,cc)
Pelron Corp., Ill (p,x,y)
Penn Fibre & Specialty Co., Inc., Pa (cc)
Philrus Products Co., NJ (cc,dd)
Pittsburgh Plate Glass Co., Pa (p,u, x,y)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Plumb Chemical Corp., Pa (y)
Polycast Corp., Conn (cc)
Polygon Plastic Co., Ind (bb,ee)
Porter, William Co., Calif (ee)
Precision Paper Tube Co., Ill (ee)
Prince Rubber & Plastics Co., Inc., NY (cc)
Reichhold Chemicals, Inc., NY (p,u,x)
Robertson, H.H. Co., Pa (p)
Rohm & Haas Co., Pa (x,y)
Roller Reinforced Plastics, Ohio
Rubber Corp. of America, NY (u)
Schori Process Div., Ferro-Co Corp., NY (cc,ee)
Schramm Fiberglass Products, Inc., Ill (u,x,y)
Schwab Plastic Corp., Mich (u)
Schwartz Chemical Co., Inc., NY (x)
Sheller Mfg. Corp., Mich (u)
Sherwin-Williams Co., Ohio (p)
Sierracin Corp., Calif (cc)
Spaulding Fibre Co., Inc., NY (bb, cc)
Specialty Resins Co., Calif (p,x)
Stokes Molded Products Div., Electric Storage Battery Co., NJ
Strick Plastics Co., Pa (u,cc,dd)
Sun Chemical Corp., Electro Technical Div., NJ (p,x)
Swedlow, Inc., Calif (cc)
Tanner Engineering Co., Calif (ee)
Thalco, Calif (p)
United Shoe Machinery Corp., Mass (x)
U.S. Polymeric Chemicals, Inc., Conn (s,y)
U.S. Rubber Co., NY (p,u,x)
Varflex Corp., NY (ee)
Wasco Products, Inc., Mass (cc)
Western Backing Corp., Calif (y)
Williamson Adhesives, Inc., Ill (y)
Witco Chemical Co., Ill (p,u)
Woodall Industries, Inc., Mich (y)
Zenith Plastics Co., Sub. of Minnesota Mining & Mfg. Co., Calif (u)

Polyethylenes

aaRBee Plastic Co., Calif (y)
Acadia Synthetic Products Div., Western Felt Works, Ill (ee)
Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
Advance Screw Products Co., Inc., Wis (bb)
Aladdin Transparent Packaging Corp., NY (t,ee)
Allied Chemical Corp., Plastics Div., NY (p,y)
Allied Resinous Products, Inc., Ohio (y,bb,cc,dd,ee)
Alpha Wire Corp., NY (ee)
American Agile Corp., Ohio (bb,cc,dd, ee)
American Hard Rubber Co., Div. of Amerace Corp., NY (bb,dd)
American Molding Powder & Chemical Co., NY (y)
Anchor Plastics Co., Inc., NY (bb,dd, ee)
Anderson Asso., Inc., Ohio (y)
Anesit Co., Ill (ee)
Argo Plastic Products Co., Ohio (cc, ee)
Auburn Plastic Engineering, Ill (t,bb, cc,ee)
Auburn Plastics Inc., NY (bb,cc,dd,ee)
Bamberger, Claude P., Inc., NJ (p,y)
Blacher, B., NY (t)
Blank, Arthur & Co., Inc., Mass (t)
Blossom Mfg. Co., Inc., NY (t,cc)
Bolta Products Div., General Tire & Rubber Co., Mass (s)
Cadillac Plastic & Chemical Co., Mich (t,bb,cc,dd,ee)
Campco Div., Chicago Molded Products Corp., Ill (t,cc)
Carroll, J.B. Co., Ill (cc)
Catalin Corp. of America, NY (y)

Celanese Polymer Co., Div. of Celanese Corp. of America, NJ
(p,y)—Ad pp 224-225

Celluplastic Corp., NJ (bb,ee)
Chester Packaging Div., St. Regis Paper Co., NY (t,cc)
Chippewa Plastics Co., Wis (t,ee)
Clopay Corp., Ohio (t,cc)
Clover Industries, Inc., NY (y)
Colonial Kolonite Co., Ill (bb,cc,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)
Conneaut Rubber & Plastics Co., Div. of U.S. Stoneware Co., Ohio (bb, cc,dd,ee)
Contour Extrusion Co., NY (t,bb,cc,dd, ee)
Copper and Brass Sales, Inc., Mich (ee)
Crane Plastics, Inc., Ohio (bb,dd,ee)
Crescent Plastics, Inc., Ind (ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (s,bb,cc,dd,ee)
Danielson Mfg. Co., Conn (bb)
Dapol Plastics, Inc., Mass (y)
Davis, Joseph Plastics Co., NJ (t,y, bb,cc,dd,ee)
Denver Plastics, Inc., Colo (t,u,bb,cc, dd,ee)
Designers Metal Corp., Ill (cc)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)

Dow Chemical Co., Plastics Div., Mich
(p,t,u,y)—Ad pp 249-256

du Pont de Nemours, E. I. & Co., Inc., Del (p,y)
Dura-Lee Corp., Kan (t)
Durable Formed Products, Inc., NY (cc,ee)
Durethene Corp., Ill (t)
Eastman Chemical Products, Inc., Sub. of Eastman Kodak Co., NY (p,u,y)
Eclipse Plastic Industries, Inc., Fla (bb,cc,dd,ee)
Extruders, Inc., Calif (t)
Firestone Plastics Co., Pa (s,t)
Flexible Packaging Div., Continental Can Co., Inc., Ohio (t,cc)
Foamade Industries, Mich (u,cc,dd)
Foss Mfg. Co., Id (t)
Foster Grant Co., Mass (t)
Fox Edge Co., Inc., Mass (s)
Frank, J. P. Chemical & Plastic Corp., NY (t,cc)
Fry Plastics International, Calif
Galigher Co., Utah (bb,cc,dd,ee)
Garlock Packing Co., NY (y)
Geauga Industries Co., Ohio (bb,dd)
General Electric Co., NY (t)
General Gasket, Inc., Conn (t,cc)
General Plastics Corp., Ind (cc)
General Plastics Mfg. Co., Wash (cc)
General Tire & Rubber Co., Ind (t,cc)
Genesee Laboratory, Inc., NY (ee)
Gering Plastics, Div. of Studebaker-Packard Corp., NJ (t,u,y,bb,cc,dd, ee)
Glass Laboratories, NY (bb,dd,ee)
Goodrich-Gulf Chemicals, Inc., Ohio (p)
Grace, W.R. & Co., Polymer Chemicals Div., NJ (p,y)
Grigoleit Co., Ill (p,s)
H & R Plastics Industries, Inc., Pa (t,bb,cc,dd,ee)
Hall Mfg. Corp., NJ (dd,ee)
Hastings & Co., Inc., Pa (t)
Hercules Powder Co., Inc., Del (p,y)
Heyden Newport Chemical Corp., American Plastics Corp. Div., NY (bb,cc,ee)
Hydrawlik Co., NJ (bb,dd)
Industrial Plastics Corp., Ind (bb,dd)
Insulation Mfrs. Corp., Ill (cc,ee)
Jet Specialties Co., Inc., Calif (bb,cc, dd,ee)
KSH Plastics, Inc., Mo (bb,cc,dd)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Kaykor Industries, Inc., Div. of Kaye-Tex Mfg. Corp., NJ (cc)
Koppers Co., Inc., Plastics Div., Pa (p,y)
Kuss, R.L. & Co., Inc., Ohio (t)
Ludlow Plastics, Mass (t)
Luminous Resins, Inc., Ill (y)
Lus-Trus Corp., Mich (cc,ee)
Maloney, F.H. Co., Tex (y)
Manufacturers Corp., Ohio (ee)
Mason Envelope Co., Inc., NY (t)
Mayon Plastics, Minn (ee)
Michelman Chemicals, Inc., Ohio
Midwest Plastic Products Co., Ill (t, cc)

Monsanto Chemical Co., Plastics Div., Mass
(p,y)—Ad pp 212-213

Moore, Samuel & Co.,Ohio (ee)
Muehlstein, H & Co., Inc., NY (y)
Murray, A.B. Co., Inc., NJ (ee)
Nalge Co., Inc., NY (ee)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
National Tube Div., U.S. Steel Corp., Pa (ee)
New England Tape Co., Div. of United-Carr Fastener Corp., Mass (dd)
Olin Mathieson Chemical Corp., Packaging Div., NY (t,ee)
Omni Products Corp., NY (y)
Ormond Mfg. Co., Inc., NJ (cc,dd)
Pacific Coast Foil Co., Calif (t)
Panelyte Div., St. Regis Paper Co., NJ (t,cc,ee)
Penn Fibre & Specialty Co., Inc., Pa (bb,cc,dd,ee)
Perfex Plastics, Inc., Ill (bb,dd,ee)
Phillips Chemical Co., Okla (p)
Plastic Compounding Corp., Sub. of Plastiglide Mfg. Co., Calif (y)
Plastic Materials, Inc., NY (y)
Plastic Packaging Co., Ill (t)
Plax Corp., Conn
Polo Plastics Co., Wis (t)
Poly Plastic Products, Inc., NJ (t, cc)
Precision Paper Tube Co., Ill (cc)
Prince Rubber & Plastics Co., Inc., NY (bb,cc,dd,ee)
Pyramid Industries, Inc., Pa (ee)
Pyramid Plastics, Inc., Ill (dd,ee)
Reed Plastics Corp., Mass (y)
Reliance Plastic & Chemical Corp., NJ (t,bb,dd)
Reynolds Aluminum Supply Co., Ga (t)
Reynolds Metals Co., Va (t,cc)
Ross & Roberts, Inc., Conn (t)
Rubber & Plastics Compound Co., Inc., NY (t)
Russell Mfg. Co., Conn (s)
Ryerson, Joseph T. & Son, Inc., Ill (ee)
Schwab Plastic Corp., Mich (u,bb,cc, dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Seiberling Rubber Co., Plastics Div., Ohio (bb,cc)
Shaw-Kendall Engineering Co., Ohio (ee)
Sheller Mfg. Corp., Mich (u)
Simon Products Co., Ill (t)
Snyder Mfg. Co., Inc., Ohio (t,cc)
Southern Plastics Co., SC (bb,cc,dd,ee)
Spencer Chemical Co., Mo (p,x,y)
Staver Co., Inc., NY (cc,dd)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Mfg. Co., Pa (dd)
Superior Plastics, Inc., Ill (bb,cc,dd, ee)
Supplex Co., Div. of Amerace Corp., NJ (y,dd,ee)
Technical Tape Corp., NY (t,cc,ee)
Thombert, Inc., Iowa (cc,ee)
Triangle Conduit & Cable Co., Inc., NJ (ee)
Toyad Corp., Pa (u)

Union Carbide Plastics Co., Div. of Union Carbide Corp., NY
(p,y)—Ad p 261

U.S. Industrial Chemicals Co., Div. of National Distillers & Chemical Corp., NY (p,t,x,y)
U.S. Stoneware Co., NY (ee)
Varflex Corp., NY (ee)
Visking Co., Div. of Union Carbide Corp., Ill (t)
Vogt Mfg. Corp., NY (bb,dd)

Vulcan Div., Reeves Bros., Inc., NY
(s,bb,dd,ee)—Ad p 319

Western Felt Works, Ill (cc)
Western Plastics Corp., Neb (bb,dd,ee)
Western Plastics Corp., Wash (ee)
Westlake Plastics Co., Pa (t,bb,cc,dd, ee)
William Brand-Rex Div., American Enka Corp., Mass (ee)
Woodall Industries, Inc., Mich (cc)
World Plastics, NY (bb,cc,dd,ee)

Polypropylene

Anchor Plastics Co., Inc., NY (bb, dd,ee)
Argo Plastic Products Co., Ohio (cc, dd,ee)

Avi Sun Corp., Pa
(y)—Ad pp 226-227

Cadillac Plastic & Chemical Co., Mich (cc,t)
Campco Div., Chicago Molded Products Corp., Ill (t,cc)
Catalin Corp. of America, NY (y)
Chemore Corp., NY (p,s,y)
Chippewa Plastics Co., Wis (t)
Conneaut Rubber and Plastics Co., Div. of U. S. Stoneware Co., Ohio (bb,cc,dd,ee)
Crane Plastics, Inc., Ohio (bb,dd,ee)
Dow Chemical Co., Plastics Div., Mich (y)
Dura-Lee Corp., Kan (t)

Eastman Chemical Products, Inc., Sub. of Eastman Kodak Co., NY (p,y)
Enjay Chemical Co. Div., Humble Oil & Refining Co., NY
(y)—Ad p 230
Gering Plastics Div., Studebaker-Packard Corp., NJ (y,bb,dd,ee)
Hall Mfg. Corp., NJ (dd,ee)
Hercules Powder Co., Del (y)
Industrial Rayon Corp., NY (s)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Ludlow Plastics, Mass (t)
Madin Plastics Inc., NJ (y,cc)
Nalge Co., Inc., NY (ee)
Nixon-Baldwin Chemicals, Inc., NJ (cc)
Novamont Corp., NY (p,y)
Prince Rubber & Plastics Co., Inc., NY (cc,ee)
Southern Plastics Co., SC (bb,cc,dd,ee)
Spencer Chemical Co., Mo (y)
Texas Eastman Co., Div. of Eastman Kodak Co., Tex (y)
Union Carbide Plastics Co. Div., Union Carbide Corp., NY
(p,y)—Ad p 261
Visking Co., Div. of Union Carbide Corp., Ill (t)

Polystyrenes

(Incl. copolymers and modifications)

aaRBee Plastic Co., Calif (y)
Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
Ambassador Plastics & Mfg. Corp., Ill (u)
American Cyanamid Co., Plastics & Resins Div., NY (y)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,cc,dd,ee)
Anchor Plastics Co., Inc., NY (bb,dd,ee)
Anderson Asso., Inc., Ohio (y)
Anesit Co., Ill (ee)
Auburn Plastic Engineering, Ill (bb,cc,ee)
Auburn Plastics, Inc., NY (bb,cc,dd,ee)
Bamberger, Claude P., Inc., NJ (p,y)
Blaak, Arthur & Co., Inc., Mass (cc)
Bolta Products Div., General Tire & Rubber Co., Mass (t,cc)
Cadillac Plastic & Chemical Co., Mich (bb,cc,dd,ee)
Campco Div., Chicago Molded Products Corp., Ill (t,cc)
Catalin Corp. of America, NY (y)
Chemical Development Corp., Mass (p)
Coating Products, Inc., NJ (t,cc)
Colonial Kolonite Co., Ill (bb,cc,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd)
Conneaut Rubber & Plastics Co., Div. of U.S. Stoneware Co., Ohio (bb,cc,dd,ee)
Crane Plastics, Inc., Ohio (bb,dd,ee)
Crescent Plastics, Inc., Ind (ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (bb,cc,ee)
Dapol Plastics, Inc., Mass (y)
Deever Plastics, Inc., Colo (u)
Dewey & Almy Chemical Div., W. R. Grace & Co., Mass (p)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Dow Chemical Co., Plastics Div., Mich
(p,t,u,y)—Ad pp 249-256
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y)
Dura Plastics of New York, Inc., NY (bb,cc)
Dyna-Therm Chemical Corp., Calif (p)
Eclipse Plastic Industries, Inc., Fla (bb,cc,dd,ee)
Emerson & Cuming, Inc., Mass (u,x,bb)
Fiberfil, Inc., Ind (y)
Foam Products, Inc., Pa
Fome-Cor Corp., Mass (u,cc)
Foster Grant Co., Mass (p,t,y,cc)
Fry Plastics International, Calif (cc)
Gallagher Co., Utah (bb,cc,dd,ee)
General Plastics Corp., Ind (cc)
Gering Plastics, Div. of Studebaker-Packard Corp., NJ (y,bb,dd,ee)
Glass Laboratories, NY (bb,dd,ee)
Glo-Brite Products, Inc., Ill (u,y,cc)
Goodyear Tire & Rubber Co., Ohio (y)
Grace, W. R. & Co., Polymer Chemicals Div., NJ (p,y)
H & R Plastics Industries, Inc., Pa (bb,cc,dd,ee)
Hall Mfg. Corp., NJ (dd,ee)
Haskelite Mfg. Div., Evans Products Co., Mich (u)
Hayden Wire Works, Inc., Mass (x)
Heyden Newport Chemical Corp., American Plastics Corp. Div., NY (bb,cc,dd,ee)
Industrial Plastics Corp., Ind (bb,dd)
KSH Plastics Inc., Mo (bb,cc,dd)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Kaykor Industries, Inc., NJ (cc)
Koppers Co., Plastics Div., Pa
(p,u,y)—Ad pp 228-229
Laminated Plastex Corp., Ohio (x,cc)
Lone Star Plastics Co., Inc., Tex (u)
Luminous Resins, Inc., Ill (y)
Lus-Trus Corp., Mich (cc,ee)
Maloney, F.H. Co., Tex (x,y)
Manufacturers Corp., Ohio (ee)
Marbon Chemical Div., Borg-Warner Corp., Ind (p,y)
Midwest Plastic Products Co., Ill (t,cc)
Monsanto Chemical Co., Mass
(p,y)—Ad pp 212-213
Muehlstein, H. & Co., Inc., NY (p,y)
Murray, A.B. Co. Inc., NJ (ee)
Nesbitt Industries, Inc., Ill (u)
Nixon-Baldwin Chemicals, Inc., NJ (cc)
Northwest Plastics Industries, Inc., Wash (u)
Omni Products Corp., NY (y)
O'Sullivan Rubber Corp., Plastics Div., Va (t,cc)
Panelyte Div., St. Regis Paper Co., NJ (u,bb,cc)
Perfex Plastics, Inc., Ill (bb,dd,ee)
Plastic Materials, Inc., NY (y)
Plax Corp., Conn (t,cc)
Polycast Corp., Conn (cc)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa
(bb,cc)—Ad p 264
Precision Paper Tube Co., Ill (ee)
Prince Rubber & Plastics Co., Inc., NY (bb,cc,ee)
Pyramid Plastics, Inc., Ill (dd,ee)
Reed Plastics Corp., Mass (y)
Rexall Chemical Co. Div., Rexall Drug & Chemical Co., NJ
Schwab Plastic Corp., Mich (u,bb,cc,dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Seiberling Rubber Co., Plastics Div., Ohio (bb,cc)
Sheffield Plastics Co., Mass (cc)
Sheller Mfg. Corp., Mich (u)
Snyder Mfg. Co., Inc., Ohio (t,cc)
Southern Plastics Co., SC (bb,cc,dd,ee)
Stauffer Chemical Co., Molded Products Div., Calif (u)
Sterling Models, Pa (u)
Strick Plastics Co., Pa (u)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., Ill (bb,cc,dd,ee)
Toyad Corp., Pa (u)
Union Carbide Plastics Co., Div. of Union Carbide Corp., NY
(p,y)—Ad p 261
United Shoe Machinery Corp., Mass (p,u)
Visking Co., Div. of Union Carbide Corp., Ill (t)
Western Felt Works, Ill (cc)
Western Plastics Corp., Neb (bb,dd,ee)
Western Plastics Corp., Wash (ee)
Westlake Plastics Co., Pa (t,y,bb,cc,dd,ee)
William Brand-Rex Div., American Enka Corp., Mass (bb,cc)
Woodall Industries, Inc., Mich (cc)
World Plastics, NY (bb,cc,dd,ee)

Polysulfide Rubber

Adhesive Products Corp., NY (x)
Armstrong Cork Co., Pa (bb,cc,dd)
Belko Corp., Md (y)
Bond International, Inc., Mich (y,ee)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chemical Coatings & Engineering Co., Inc., Pa (x,y)
Chicago-Allis Mfg. Corp., Ill (p)
Coast Pro-Seal Mfg. Co., Calif (y)
Dayton Rubber Co., Ohio (y,bb,cc,dd,ee)
Garlock Packing Co., NY (y,cc)
Hiller Aircraft Corp., Adhesive Engineering Div., Calif (x)
Home Rubber Co., NJ (y,bb,cc,dd)
Maloney, F.H. Co., Tex (y)
Moxness Products, Inc., Wis (bb,cc,dd,ee)
Paeco Rubber Co., Inc., Ohio (y,dd,ee)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (y)
Parker, Stearns & Co., Inc., NY (y,bb,cc,dd,ee)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Polymer Industries Inc., Conn (x)
Products Research Co., Calif (y)
Raybestos-Manhattan, Inc., Plastic Products Div., Pa (x)
Thiokol Chemical Corp., NJ (p,x,y)
Toyad Corp., Pa (u)
Trostel, Albert Packing, Ltd., Wis (y)
Vulcan Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Polyvinyl Alcohols

(see Vinyls)

Polyvinyl Chloride and Copolymers

(see Vinyls)

Porcelain

(see Ceramics)

Porcelain Enamels

(see Inorganic Coatings)

Powdered Metals

(see Iron Powders or specific metal)

Precoated Metals —Aluminized

American Chain & Cable Co., Pa (g)
Armco Steel Corp., Ohio (g)
Bethlehem Steel Co., Pa (g)
Biersach & Niedermeyer Co., Wis (a)
Brasco Mfg. Co., Ill (g)
Colonial Alloys Co., Pa. (a)
Enamel Products Co., Ohio (g)
Gillett & Eaton, Inc., Minn (c)
Grigoleit Co., Ill (a)
Ideal Can Co., Mass (g)
Jackson Steel Products, Inc., NY (g)
Kassel Export Co., Inc., NJ (c,g)
Kees, F.D. Mfg. Co., Neb (g)
Mayville Metal Products Co., Wis (g)
National Galvanizing Co., Pa (g)
National-Standard Co., Mich
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (g)
Rome Mfg. Div., Revere Copper & Brass, Inc., NY (g)
Sager Metal Strip Co., Ill (a)
Simoniz Products Div., Simoniz Co., Ill (a,g)
Sun Steel Co., Ill (g)
Tickle, Arthur Engineering Works, Inc., NY (c,f,g,h)
Wall Colmonoy Corp., Mich (g)
Whitehead Metal Products Co., Inc., NY (g)
Whyte, Oliver Co., Inc., Mass (g)

Precoated Metals —Galvanized

Albert Pipe Supply Co., Inc., NY (g)
Anderson-Bolling Mfg. Co., Mich (g)
Appalachian Steel Corp., NJ (g)
Armco Steel Corp., Ohio (g)
Associated Spring Corp., Wallace Barnes Div., Conn (g)
Atlantic Steel Co., Ga (g)
Bethlehem Steel Co., Pa (g)
Biersach & Niedermeyer Co., Wis (g)
Bignall Co., NY (c)
Brasco Mfg. Co., Ill (g)
Brewer-Titchener, Corp., NY (g)
Byers, A.M. Co., Pa (c)
Castle, A.M. & Co., Ill (a,g)
Central Steel & Wire Co., Ill (g)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (g)
Conner Mfg. Co., Ky (g)
Continental Nu-Steel Metal Products Div., Continental Wire & Iron Works, Ill (g)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Continental Steel Corp., Ind (g)
Edgcomb Steel & Aluminum Corp., NJ (g)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (g)
Enterprise Galvanizing Co., Pa (g)
Grand Sheet Metal Products Co., Consumer Products Div., Ill (c)
Granite City Steel Co., Ill (g)
Hobbs, Clinton E. Co., Mass (c,g)
Ideal Can Co., Mass (g)
Jackson Steel Products, Inc., NY (g)
Kelley Mfg. Co., Tex (g)
Koehler Mfg. Co., Mass (c,g)
Levinson Steel Co., Pa (g)
Mahon, R.C. Co., Mich (g)
Mayville Metal Products Co., Wis (g)
McNally Pittsburg Mfg. Co., Kan (g)
National Galvanizing Co., Pa (g)
National Tube Div., U.S. Steel Corp., Pa (g)
National-Standard Co., Worcester Div., Mass (g)
New York Iron Roofing & Corrugating Co., Inc., NJ (g)
Newport Steel Corp., Ky (g)
Nikoh Tube Co., Ill (g)
Northwestern Steel & Wire Co., Ill (g)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (g)
Republic Steel Corp., Ohio (g)
Riverside Foundry & Galvanizing Co., Mich (c,g)
Roebling's, John A. Sons Div., Colorado Fuel & Iron Corp., NJ (g)
Rome Mfg. Div., Revere Copper & Brass, Inc., NY (g)
Ryerson, Joseph T. & Son, Inc., Ill (g)
Sharon Steel Corp., Pa (g)
Sherman & Reilly, Inc., Tenn (e,f,g)
Simoniz Products Div., Simoniz Co., Ill (g)
Solar Steel Corp., Ohio (g)
Southern Galvanizing Co., Md (g)
Southern Metal Products Co., La (g)
Stainless and Strip Div., Jones & Laughlin Steel Corp., Ohio (g)
Stenman, Bror F., Mass (g)
Sun Steel Co., Ill (g)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (g)
Thomas Strip Div., Pittsburgh Steel Co., Pa (g)
U. S. Steel Corp., Pa (g)
U.S. Steel Supply Div., U.S. Steel Corp., Ill (g)
Vulcan Rail & Construction Co., NY (g)
Weirton Steel Co., Div. of National Steel Corp., W.Va (g)
Wesbar Stamping Corp., Wis (c,g)
Wheeling Steel Corp., W. Va (g)—Ad pp 84-85
Witt Cornice Co., Galvanizing Div., Ohio (g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)
Youngstown Sheet & Tube Co., Ohio (g)

Precoated Metals —Lead or Terne-Coated

Acme Stamping & Wire Forming Co., Pa (a,b,g)
Anderson-Bolling Mfg. Co., Mich (g)
Appalachian Steel Corp., NJ (g)
Armco Steel Corp., Ohio (c,g)
Biersach & Niedermeyer Co., Wis (g)
Brasco Mfg. Co., Ill (g)
Cartwright, R. Tube Products Co., Mich (g)
Caspers Tin Plate Co., Ill (g)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (g)
Composite Industrial Metals, Inc., RI (a,b,c,d,e,f,g,h,l)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (g)
Follansbee Steel Corp., Sheet Metal Specialty Div., W.Va (g)
Hayden Wire Works, Inc., Mass (d)
Higbie Mfg. Co., Mich (g)
Houston Blow Pipe & Sheet Metal Works, Tex (g)
Ideal Can Co., Mass (g)
Langenkamp, F.H. Co., Ind (b)
National Lead Construction Co., Inc., Pa (d)
New Haven Copper Co., Conn (b)
Nikoh Tube Co., Ill (g)
Philadelphia Steel & Wire Corp., Pa (g)
Presswork, Inc., Mich (b,g)
Reactive Metals, Inc., Ohio (g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (b)
Rome Mfg. Co., Revere Copper & Brass, Inc., NY (g)
Ryerson, Joseph T. & Son, Inc., (g)
Sharon Steel Corp., Pa (g)
Solar Steel Corp., Ohio (g)
Steel Protection & Chemical Co., Ind (a,b,c,f,g)
Sun Steel Co., Ill (g)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (g)
Thomas Strip Div., Pittsburgh Steel Co., Pa (g)
U.S. Steel Supply Div., U.S. Steel Corp., Ill (g)
Wayne Foundry & Stamping Co., Mich (g)
Wesbar Stamping Corp., Wis (c,g)
Wheeling Steel Corp., W.Va (g)
Whitehead Metal Products Co., Inc., NY (b,g)
Wright Metalcoaters, NJ (a,b,c,e,f,g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)

Precoated Metals —Tin-Coated

Acme Stamping & Wire Forming Co., Pa (a,b,g)
American Silver Co., NY (a,b,e,f,g)
Anderson-Bolling Mfg. Co., Mich (g)
Appalachian Steel Corp., NJ (g)
Association Spring Corp., Wallace Barnes Steel Div., Conn (g)
Bethlehem Steel Co., Pa (g)
Brasco Mfg. Co., Ill (g)
Caspers Tin Plate Co., Ill (g)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (g)
Composite Industrial Metals, Inc., RI (a,b,c,d,e,f,g,l)
Conner Mfg. Co., Ky (g)
Granite City Steel Co., Ill (g)
Inland Steel Co., Ill (g)
Kaiser Steel Corp., Calif (g)
Koehler Mfg. Co., Mass (c,g)
Lundquist Tool & Mfg. Co., Inc., Mass (a,g)
Olean Electro Plating Co., NY
Philadelphia Steel & Wire Corp., Pa (g)
Republic Steel Corp., Ohio (g)
Riverside Foundry Co., Pa (c)
Smithers Tool & Machine Products, Inc., NY (g)
Solar Steel Corp., Ohio (g)
Somers Brass Co. Inc., Conn (b,f)
Stainless and Strip Div., Jones & Laughlin Steel Corp., Ohio (g)
Steel Protection & Chemical Co., Ind (a,b,c,f,g)
Sun Steel Co., Ill (g)
U. S. Steel Corp., Pa (g)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (g)
Wabash Metal Products Co., Inc., Ind (g)
Weirton Steel Co., Div. of National Steel Corp., W.Va (g)
Wheeling Steel Corp., W.Va (g)
Wright Metalcoaters, NJ (a,b,c,e,f,g)
Youngstown Sheet & Tube Co., Ohio (g)

Pre-Impregnated Materials for Plastic Laminates

American Plastics Corp., NY (l)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Cincinnati Industries Inc., Ohio (k)
Coast Mfg. & Supply Co., Calif (l)
Cordo Chemical Corp., Conn (k,l,m)
Cordo Molding Products, Inc., Conn (l)
Durel, Inc., Iowa (l)
Eljay Corp., Md (k,l)
Emerson & Cuming, Inc., Mass (k,l,m)
Fabricon Products Div., Eagle-Picher Co., Mich (l)
Firmaline Products of Crompton & Knowles, NJ (k,l)
Flexfirm Products, Calif (k,l)
Flexible Tubing Corp., Conn (k)
Glastic Corp., Ohio (l)
Haveg Industries Inc., Del (l)
Luminous Resins Inc., Ill (k)
Maloney, F.H. Co., Tex (l)
Micarta Div., Westinghouse Electric Corp., SC (l)
Minnesota Mining & Mfg. Co., Minn (l)
Minnesota Mining & Mfg. Co., Reinforced Plastics Div., Minn (l)
Modiglass Fibers, Inc., NJ (k,l)
Narmco Industries, Inc., Narmco Materials Div., Calif (l)
New England Laminates Co., Conn (l)
Panelyte Div., St. Regis Paper Co NJ (l)
Raybestos Div., Raybestos-Manhattan, Inc., Conn (l)
Riegel Paper Corp., NY (k,l)
Rogers Corp., Conn (l)
Russell Mfg. Co., Conn (l)
Spaulding Fibre Co., Inc., NY (l)
Standard Insulation Co., Plastics Div., NJ (l)
Sun Chemical Corp., Electro Technical Div., (k,l,m)
Swedlow, Inc., Calif (l)
U.S. Polymeric Chemicals, Inc., Conn (l,m)
Western Backing Corp., Calif (k,l,m)

Prepainted Metals

(see Organic Coatings)

Preplated Metals

(chromium, nickel)

Acme Stamping & Wire Forming Co., Pa (a,b,g)
Aluminum Co. of America, Pa (a)
American Nickeloid Co., Ill (a,b,g,l)
American Silver Co., Inc., NY (b,f,g)
Apollo Metals, Inc., (b,c,g,l)
Benjamin Electric Mfg. Co., Ill (g)
Chromalloy Corp., NY (g)
Enamelstrip Corp., Sub. of National Steel Corp., Pa (a,b,c,f,g,h,l)
Fromson Orban Co., Inc., NY (a)
Grand Sheet Metal Products Co., Consumer Products Div., Ill (a,b,c,e,f,g,h,l)
Grigoleit Co., Ill (a,g)
Hayden Wire Works, Inc., Mass (a,b,f,l)
Haydon Corp., NY (g)
Kassel Expert Co., Inc., NJ (g)
Kroh Wagner, Ill (a,g)
Metal Trims, Inc., Miss (a)
National-Standard Co., Mich
Pittsburgh Steel Co., Pa (b,d,f,l)
Republic Steel Corp., Ohio (g)
Rigidized Metals Corp., NY (a,g)
Roebling's, John A. Sons Div., Colorado Fuel & Iron Corp., NJ (g)
Sheldon, M. L. & Co., Inc., NY (f)
Sun Steel Co., Ill (g)
Sylvania Electric Products, Inc., Parts Div., Pa (a,b,c,f,g)
Thomas Strip Div., Pittsburgh Steel Co., Pa (b,f,l)
Wright Metalcoaters, NJ (a,b,c,e,f,g)

Pressure Sensitive Tapes

(see tapes)

Protein Plastics

Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,cc,dd,ee)
American Plastics Corp., NY (bb,cc)
Borden Co., Borden Chemical Div., NY (p)
Heyden Newport Chemical Corp., American Plastics Corp. Div., NY (bb, cc,dd)
National Casein Sales, Ill (p)
Reichhold Chemicals, Inc., NY (p)

Quartz

(see Ceramics)

Rare Earth Metals

American Metallurgical Products Co., Pa
American Potash & Chemical Corp., Calif
Davison Chemical Co., Div. of W. R. Grace & Co., Md
Lindsay Chemical Div., American Potash & Chemical Corp., Ill
Mallinckrodt Chemical Works, Mo
Maywood Chemical Works, NJ
Michigan Chemical Corp., Rare Earths & Thorium Div., Mich
Molybdenum Corp. of America, Pa
Research Chemicals Div., Nuclear Corp. of America, Calif
Sintercast Div., Chromalloy Corp., NY
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
United Mineral & Chemical Corp., NY
Vitro Chemical Co., NY

Refractories, Aluminide

Commercialores, SC (aa)
Coors Porcelain Co., Colo (r,bb,ee)
Du-Co Ceramics Co., Pa (r,z,bb,ee)
Engineered Ceramics Mfg. Co., Ill (r,z,bb,ee)
France, J. H. Refractories Co., Pa
General Astrometals Corp., NY (r,aa, bb,cc,ee)
Ironton Fire Brick Co., Ohio (r)
Louthan Mfg. Co. Div., Ferro Corp., Ohio (r,z,bb,cc,ee)
Plasmadyne Corp., Calif (aa)
Wellsville Fire Brick Co., Mo (r)

Refractories, Boride

Carborundum Co., Refractories Div., NJ (r,bb,ee)
Electro Refractories & Abrasives Corp., NY (aa)
Firth Sterling, Inc., Pa (r)
General Astrometals Corp., NY (r,aa, bb,cc,ee)
National Carbon Co. Div., Union Carbide Corp., NY (aa,bb,cc)
Norton Co., Mass (r,aa)
Plasmadyne Corp., Calif (aa)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)

Refractories, Carbide

Carborundum Co., Refractories Div., NJ (r,u,aa,bb,ee)
Continental Coatings Corp., Ohio (aa)
Engineered Ceramics Mfg. Co., Ill (r,z,bb,ee)
Firth Sterling, Inc., Pa (r)
General Astrometals Corp., NY (r,aa, bb,cc,ee)
Norton Co., Mass (r,z,aa,bb,ee)
Plasmadyne Corp., Calif (aa)
Schwarzkopf Development Corp., NY (r)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)

Refractories, Nitride

Carborundum Co., Refractories Div., NJ (r,bb,ee)
Electro-Ceramics, Inc., Utah (r,z,bb, cc,ee)
General Astrometals Corp., NY (r,aa, bb,cc,ee)
National Carbon Co. Div., Union Carbide Corp., NY (aa,bb,cc)
Norton Co., Mass (r,aa)
Plasmadyne Corp., Calif (aa)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)

Refractories, Oxide

Beryllium Corp., Pa (r)—Ad p 159
Brush Beryllium Co., Ohio (r)
Carborundum Co., Refractories Div., NJ (r,s,aa,bb,ee)
Continental Coatings Corp., Ohio (aa)
Corning Glass Works, NY (r,aa)
Du-Co Ceramics Co., Pa (r,z,aa,bb,ee)
Eagle-Picher Co., Ohio (s)
Electro-Ceramics, Inc., Utah (r,z,bb, cc,ee)
Electro Refractories & Abrasives Corp., NY (r)
Electrical Refractories Co., Ohio (r,ee)
Emerson & Cuming, Inc., Mass (u,cc)
Engineered Ceramics Mfg. Co., Ill (r, z,bb,ee)
General Astrometals Corp., NY (r,aa, bb,cc,ee)
General Electric Co., Chemical Materials Dept., Mass
General Refractories Co., Pa (r,aa)
Industrial Sapphire Co., Pa (sapphire)—Ad p 314
Laboratory Equipment Corp., Mich (r, bb,ee)
Linde Co. Div., Union Carbide Corp., NY (sapphire)
Monsanto Chemical Co., Inorganic Chemicals Div., Mo (aa)
Morganite, Inc., NY (aa,bb,ee)
National Beryllia Corp., NJ (r,z,bb, cc,ee)
Norton Co., Mass (r,z,aa,bb,ee)
Plasmadyne Corp., Calif (aa)
Refractory Specialties Co., Pa (r)
Research Chemicals Div., Nuclear Corp. of America, Calif (aa,bb)
Saxonburg Ceramics, Inc., Pa (r,bb, cc,ee)
Thermal Refractories Corp., NJ (r,z, bb,cc,ee)
Thompson, H.I. Fiber Glass Co., Calif (s)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Wellsville Fire Brick Co., Mo., (r,aa)
Zirconium Corp. of America, Ohio (r, u,z,aa,bb,ee)

Refractories, Silicide

Carborundum Co., Refractories Div., NJ (r,z,bb,ee)
Du-Co Ceramics Co., Pa (r,z,bb,ee)
Eagle-Picher Co., Ohio (s)
Electrical Refractories Co., Ohio (r)
Engineered Ceramics Mfg. Co., Ill (r,z,bb,ee)
General Astrometals Corp., NY (r,aa, bb,cc,ee)
General Ceramics Div., Indiana General Corp., NJ (r)
Haynes Stellite Co., Div., Union Carbide Corp., NY (r)
Ironton Fire Brick Co., Ohio (r)
Louthan Mfg. Co. Div., Ferro Corp., Ohio (r,z,bb,cc,ee)
Plasmadyne Corp., Calif (aa)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Wellsville Fire Brick Co., Mo., (r,aa)
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif (r, z,bb,cc)

Reinforced Plastics

(see Laminates)

Rhenium

Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (aa, bb,dd,ff)
Hardy, Charles, Inc., NY (aa)
Mallory, P.R. & Co., Inc., Ind (bb)
Nuclear Metals, Inc., Mass (w,bb)
Shieldalloy Corp., NJ (aa)
University of Tennessee, Dept of Chemistry, Tenn (aa)

Rock Wool

(see Inorganic Fibers)

Rod

(see specific material)

Rods, Welding

(see Filler Metals)

Roll Formed Parts

Abalon Precision Mfg. Corp., NY (a, b,c,g)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (g)
Alloy Products Corp., Wis (a,f,g,h)
Aluminum Co. of America, Pa (a)
American Car & Foundry Div., ACF Industries, Inc., NY (a,e,g)
American Nickel Alloy Mfg. Corp., NY (f)
American Pipe & Construction Co., Northwest Div., Ore (g)
American Welding and Mfg. Co., Ohio (a,f,g,h)
Ampco Metal, Inc., Wis (b)
Arrow Metal Products Corp., NJ (a)
Beck, I. & Sons, Inc., NY (a,b,g)
Bethlehem Steel Co., Pa (g)
Biersach & Niedermeyer Co., Wis (a, b,c,g)
Binkley Co., Mo (g)
Brown Lipe Chapin Div., General Motors Corp., NY (a,g)
Brush Beryllium Co., Ohio (b)
Bunker Hill Co., Calif (d)
Burkhardt Steel Co., Colo (c,g)
Butler Mfg. Co., Mo (a,g)
Byers, A.M. Co., Pa (c)
Carbo Tool & Die Co., Ohio (c)
Chicago Screw Co., Div. of Standard Screw Co., Ill (a,b,c,f,g)
Coast Pro-Seal & Mfg. Co., Calif (a, b,f,g,h,j)
Craft Mfg. Co., Ill (f,g)
Day Co., Minn (a,g)
Division Lead Co., Ill (d)
Dresser Mfg. Div., Dresser Industries, Inc., Pa (a,f,g,h)
Eaton Mfg. Co., Reliance Div., Ohio (g)
Edgewater Steel Co., Pa (g,h)
Ellwood City Iron & Wire Co., Pa (c)
Emerson-Sack-Warner Corp., Mass (a, b,f,g)
Enamel Products Co., Ohio (c)
Fabristeel Products, Inc., Mich (g)
Falstrom Co., NJ (a,b,e,g,h)
Fitzgibbons Boiler Co., Inc., NY (c)
Fletcher Enamel Co., W.Va (a,b,c,d,e, f,g)
Greene Mfg. Co., Wis (a,g)
Grigoleit Co., Ill (a,g)
Haydon Corp., NY (a,g)
Ideal Can Co., Mass (a,b,g)
Inland Steel Co., Ill (g)
Irwin-Sensenich Corp., Pa (a,g)
Jackson Steel Products, Inc., NY (a, b,f,g,j)
Kaiser Steel Corp., Calif (g)
Kelley Mfg. Co., Tex (a,b,g)
Kelsey-Hayes Co., Mich (g)
Kling Metal Spinning & Stamping Co., NY (a,b,c,d,e,f,g,j)
Kroh Wagner, Ill (a,b)
Leach & Garner Co., Industrial Div., Mass (b,f)
Le Tourneau, R.G., Inc., Tex (g)
Lock Joint Tube Co., Inc., Ind (g)
Magnesium Products of Milwaukee, Inc., Wis (a,e)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (a,b,c,e,f,g,h)
Manufacturers & Fabricators, Inc., Ohio (f,g)
McLanahan & Stone Corp., Pa (g)
Merrimac Brass, Mass (b,f)
Metal Forming Corp., Div. of Vanadium-Alloys Steel Co., Ind (a,b,f,g)
Midvale-Heppenstall Co., Pa (c,f,g)
Mirro Aluminum Co., Wis (a)
Morse, Fred W. Co., RI (a,b,c,g,j)
Morton Mfg. Co., Ill (a,g)
National Aluminum Co., Ohio (a,g)
National Metal Products Co., Pa (a, b,g,j)
National Screw & Mfg. Co., Ohio (b,g)
Nikoh Tube Co., Ill (g)
Nippert Electric Products Co., Ohio (b)
Parish Pressed Steel Div., Dana Corp., Pa (g)
Pfister Tubing Corp., NJ (a)
Posey Iron Works, Inc., Pa (g)
Pyramid Mouldings, Inc., Ill (a,b,c,g)
Regal Ware, Inc., Wis (a,b,g)
Revere Copper & Brass, Inc., Ill (a,b, c,f,g,j)
Reynolds Aluminum Supply Co., Ga (a)
Rockwell Engineering Co., Ill (a,b,c,g)
Rohr Aircraft Corp., Calif (a)
Roll Formed Products Co., Ohio (a,b,g,h)—Ad p 432
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
Sager Metal Strip Co., Ill (a,b,c,j)
Schlegel Mfg. Co., NY (a,b,g)
Security Cos., Mich (a)
Security Sash & Screen Co., Mich (a)
Serrick Corp., Acme-Lees Div., Ind (a,g)
Stainless and Strip Div., Jones & Laughlin Steel Corp., Ohio (g)
Standard Pressed Steel Co., Pa (b,g)
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (g)
Stanwood Corp., Ill (g)
Sylvania Electric Products, Inc., Parts Div., Pa (b,f,g)
Textron Metals Co., Ohio (a)
Thompson Pipe & Steel Co., Colo (a,b, c,d,e,f,g)
Torrington Co., Conn (a,b,f,g)
U.S. Graphite Co., Div. of Wickes Corp., Mich (aa)
Universal-Cyclops Steel Corp., Pa (f,g)
Vanadium-Alloys Steel Co., Pa (g)
Vulcan Mfg. Co., Ohio (a,b,c,f,g)
Vulcan Metal Products, Inc., Ala (a)
Wal-Mar Corp., Ill (a,b,c,e,g)
Werner, R.D. Co., Pa (a,b,g,j)
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (a,b,c,f,g)
Wyatt Metal & Boiler Works, Inc., Tex (a,b,c,e,f,g)
Youngstown Mfg., Inc., Ohio (a)

Rubber, Natural

Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NY (bb,cc,dd)
American Rubber Products Corp., Ind (u,bb,cc,dd,ee)
Atlas Mineral Products Co., Pa (cc)
Auburn Rubber Co., Inc., Ind (cc)
Automotive Rubber Co., Inc., Mich (cc, dd)
Belko Corp., Md (y)
Bond International, Inc., Mich (y,ee)
Broadway Rubber Corp., Ky (u,cc)
Brown Rubber Co., Inc., Ind (u)
Buffalo Weaving & Belting Co., NY (cc)
Capac Mfg. Corp., Mich (y,cc)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Ill (p)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio (y)
Continental Rubber Works, Pa (bb,cc, dd,ee)
Coyne & Paddock, Inc., NY (cc)
Dayton Rubber Co., Ohio (u,y,bb,cc,dd, ee)
Douglas & Sturgess, Calif (x,y)
Johns-Manville Corp., Dutch Brand Div., Ill (u,y,cc,dd)
Faultless Rubber Co., Ohio (u,y,bb,ee)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (s,u,y,cc,ee)
Flexible Tubing Corp., Conn (ee)
Foam Products, Inc., Pa (u)
Foamade Industries, Mich (u)
Garlock Packing Co., NY (y,bb,cc,dd, ee)
Geauga Industries Co., Ohio (y,bb,dd)
Goodrich, B.F. Chemical Co., Sponge Products Div., Conn (u)
Goshen Rubber Co., Inc., Ind (y)
Hardman, H.V. Co., Inc., NJ (x)
Hayes Adhesive Co., Inc., Mo (y)
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd,ee)
Johns-Manville Corp., NY (cc)
Luzerne Rubber Co., NJ (bb,cc,dd,ee)
Maloney, F.H. Co., Tex (y)
Martin Rubber Co., Inc., NJ (y,dd,eee)
Mid-States Rubber Products, Inc., Ind (y)
Morningstar-Paisley, Inc., NY (y)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (u,x,y)
Paeco Rubber Co., Inc., Ohio (y)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (y)
Parker, Stearns & Co., Inc., NY (y, bb,cc,dd,ee)
Pawling Rubber Corp., NY (bb,dd,ee)
Polymer Chemical Co., Ohio (x,y)
Rand Rubber Co., NY (p,t,cc)
Raybestos-Manhattan, Inc., NJ (bb, cc,dd)
Raybestos-Manhattan, Inc., Plastic Products Div., Pa (x)

KEY

MATERIALS

- **a**—Aluminum and its alloys
- **b**—Copper and its alloys
- **c**—Iron and its alloys (except steel)
- **d**—Lead and its alloys
- **e**—Magnesium and its alloys
- **f**—Nickel and its alloys
- **g**—Steels
- **h**—Titanium and its alloys
- **j**—Zinc and its alloys
- **k**—Thermoplastics
- **l**—Thermosetting plastics
- **m**—Elastomers

BASIC FORMS

- **n**—Anodes
- **o**—Bar
- **p**—Base resins, polymers or gums
- **q**—Billets
- **r**—Custom formed parts (incl. specialties)
- **s**—Fibers
- **t**—Film
- **u**—Foams (component materials or products)
- **v**—Foil
- **w**—Ingot
- **x**—Laminating, casting resins
- **y**—Molding compounds
- **z**—Plate
- **aa**—Powder
- **bb**—Rod
- **cc**—Sheet
- **dd**—Strip
- **ee**—Tubing
- **ff**—Wire

Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p,y,bb,cc,dd,ee)
Roberts Toledo Rubber Co., Ohio (ee)
Rogers Corp., Conn (y,cc,dd)
Roth Rubber Co., Ill (y,cc)
Rubatex Div., Great American Industries, Inc., Va (u)
Rubber Corp. of America, NY (u)
Russell Mfg. Co., Conn (s)
Sheller Mfg. Corp., Mich (u)
Snyder, M.L. & Son, Inc., Pa (ee)
Standard Products Co., Mich (y)
Stockwell Rubber Co., Inc., Pa (u,y, bb,cc,dd)
Technical Specialties Co., NY (dd)
Toyad Corp., Pa (t,u)
Trostel, Albert Packing, Ltd., Wis (y)
U.S. Rubber Co., Kem-Blo Dept., Conn (u)
Vulcan Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Rubber, Synthetic

(see specific material)

Sand Castings

(see Castings)

Sandwich Materials

(key letters refer to core materials)

Aerojet-General Corp., Structural Materials Div., Calif (l)
Allegheny Ludium Steel Corp., Pa (g)
Almco Steel Products Corp., Ind (g)
Aluminum Co. of America, Pa (a)
Antara Chemicals, Div. of General Aniline & Film Corp., NY (c)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Artmor Plastics Corp., Md (a,k,l,m)
Bar-Ray Products, NY (d)
Bridgeport Brass Co., Conn (b,f,g)
Brunswick Corp., Defense Products Div., Mich (a,l)
Busch, J.C. Co., NY (a,c)
Cincinnati Industries Inc., Ohio (k)
Composite Industrial Metals, Inc., RI (a,b,c,d,e,f,g,h,j)
Continental Rubber Works, Pa (m)
Dow Chemical Corp., Plastics Div., Mich (k)
Douglas Aircraft Co., Inc., Aircomb Div., Calif (l)
Dumont Corp., Calif (a,l)
Durel, Inc., Iowa (l)
Fome-Cor Corp., Mass (k)
General Findings & Supply Co., Industrial Div., Mass (b,f)
General Tire & Rubber Co., Ind (l)
Glo-Brite Products, Inc., Ill (l)
H & R Plastics Industries, Inc., Pa (k)
Hardy Mfg. Corp., Ind (g)
Haskelite Mfg. Div., Evans Products Co., Mich (a,g,k,l,m)
Hawkeye Rubber Mfg. Co., Iowa (g,m)
Hexcel Products, Inc., Calif (a,g)
Kassel Export Co., Inc., NJ (g)
Leach & Garner Co., Industrial Div., Mass (b,f)
Lukens Steel Co., Pa (a,b,e,f,g,h)
Luminous Resins, Inc., Ill (k)
Lunn Laminates, Inc., NY (l)
Mechanical Rubber Products Co., NY (l)
Minnesota Mining & Mfg. Co., Minn (l)
Mobay Chemical Co., Pa (k)
National Moldite Co., NJ (c)
National Vulcanized Fibre Co., Del (l)
Nopco Chemical Co., Plastics Div., NJ (l)
Northwest Plastics Industries, Inc., Wash (l)
Nuclear Metals, Inc., Mass (a,b,c,e,f, g,h)
Permacel, NJ (l)
Presswork, Inc., Mich (b,d)
Pyromet Co., Calif (f)
Replac Corp., Ohio (k,l,m)
Riegel Paper Corp., NY (k,l)
Rogers Corp., Conn (l,m)
Rohr Aircraft Corp., Calif (f,g)
Russell Mfg. Co., Conn (b)
Russell Reinforced Plastics Corp., NY (l)
Shur-Lok Corp., Calif
Solar Aircraft Co., Calif (g,h)
Standard Insulation Co., NJ (l)
Standard Metals Corp., Mass (c,f)
Superior Steel Div., Copperweld Steel Co., Pa (g)
Swedlow, Inc., Calif (a,f,g,h)
Thermoid Div., H.K. Porter Co., Pa (l)
Thompson, H. I. Fiber Glass Co., Calif (l)
Toyad Corp., Pa (k)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
U.S. Polymeric Chemicals, Inc., Conn (l)
Wall Colmonoy Corp., Mich (a,b,f,g,h)
West Haven Foundry Co., Conn (a,b)
Wittman, Lawrence & Co., NY (k,l)
Zenith Plastics Co., Calif (l)

Sapphire

(see Refractories, Oxide)

Screw Machine Parts

Abalon Precision Mfg. Corp., NY (a, b,c,g)
Abbott Products, Inc., NY (a,b,c,d,e, f,g,h,j)
Advance Screw Products Co., Inc., Wis (a,b,c,g)
Affiliated Screw Products Co., Ill (a, b,c,d,e,f,g,h,j)
Albany Products Co., Inc., Conn (a, b,f)
Alden Products Co., Mass (g)
Allied Machine Products Co., Mich (a,b,g)
Allied Metal Products Co., Mass (a, b,c,g)
Allied Products Corp., Mich (g)
Allmetal Screw Products Co., Inc., NY (f,g,h)
Aluminum Co. of America, Pa (a)
American Electrical Products Co., Ohio (a,b,f,g)
American Fabricated Products Co., Ind (a,b,f,g)
American Sanitary Mfg. Co., Ill (b)
American Screw Products Co., Mich (a,b,g)
Ampco Metal, Inc., Wis (b)
Anti-Corrosive Metal Products Co., Inc., NY (g)
Approved Mfg. Co., Inc., Mich (b,g)
Argosy Products, Inc., Ohio (a,b,g)
Ashby Mfg. Co., Mo (b,f,g)
Atkins Saw Div., Borg-Warner Corp., Ind (g)
Auburn Spark Plug Co., Inc., NY (a, b,c,d,f,g,h)
Auel Industries, Pa (a,b,g)
Autel Electronics Co., Precision Machine & Welding Div., NJ (a,b,c,e, g,h)
Automatic Metal Products Corp., Mich (b,f,g,h)
Babson Dow Mfg. Co., Mass (a,b,c, f,g)
Balas Collet Mfg. Co., Ohio (a,b,f,g)
Baldwin Mfg. Co., Conn (a,b,c,d,f, g,h,j)
Barton Products Corp., Wis (a,b,c,e, f,g)
Bayley Products, Inc., Mich (a,b,g)
Beacon Metal Mfg. Co., NY (a,b,c,e, f,g,h,j)
Beck Products Corp., Mich (a,b,f,g)
Bethandale Corp., Ohio (a,b,f,g)
Bethlehem Steel Co., Pa (g)
Bickford F.H. Co., Ohio (a,b,g)
Biddle Screw Products Co., Ind (a,b, c,d,e,f,g,h)
Blacher Bros., Inc., RI (a,b,g)
Boehm Screw Products Co., Mich (a, b,f,g)
Boots Aircraft Nut Corp., Conn (a, b,f,g)
Brown Corp., NY (g)
Buchmann Spark Wheel Corp., NY (a, b,c,e,f,g)
Buckeye Brass & Mfg. Co., Ohio (b)
Burgess-Norton Mfg. Co., Ill (c)
C & G Screw Machine Products Co., Ind (a,b,g)
Carleton Screw Products Co., Minn (a, b,g)
Cartwright, R. Tube Products Co., Mich (a,b,g)
Central Screw Products Co., Mich (a, b,f,g)
Chapman Machine Co., Inc., Conn (a, b,f,g)
Chardon Metal Products Co., Ohio (a, b,f,g)
Chicago Screw Co., Div. of Standard Screw Co., Ill (a,b,c,f,g)
Clendenin Bros., Inc., Md (b)
Cleveland Cap Screw Co., Ohio (a,b, f,g,h)
Collis Co., Iowa (a,b,f,g)
Columbus Dental Mfg. Co., Ohio (a, b,c,g)
Columbus Jack Corp., Ohio (a,c,g)
Columbus Production Mfg. Co., Ohio (a,b,g)
Comerford Mfg. Co., Inc., Conn (a,b, c,e,f,g,h,j)
Condamatic Co., Inc., Mich (a,g,h)
Conn Perry Mfg. Co., Mich (b,g)
Connecticut Mfg. Co., Conn (b,f,g)
Control Parts Corp., NY (a,b,c,d,e,f, g,h,j)
Curtis Products Co., Conn (a,b,c,f,g)
Curtis Screw Co., Inc., NY (a,b,f,g)
Davis & Hemphill, Md (a,b,c)
Dawlen Corp., Mich (a,b,c,f)
Decatur Automatic Co., Ill (a,b,f,g)
Deerfield Mfg. Co., Ohio (a,b,f,g)
Defiance Screw Machine Products Div., Serrick Corp., Ohio (g)
Delo Screw Products Co., Ohio (a, b,f,g)
Delron Co., Inc., Calif (a,g)
Dependable Automatic Screw Co., Conn (a,b,c,d,e,f,g,h,j)
Dixon Corp., RI (k)
Drexel Screw Products Co., Ill (a,b, c,f,g,)
Duffin Mfg. Co., Ohio (a,b,g,h)
Duro Screw & Mfg. Co., NJ (a,b, f,g,h)
Eastern Machine & Screw Corp., Conn (a,g)
Eby, Hugh H. Co., Pa (a,b,f)
Economy Machine Products Co., Ill (a,b,f,g)
Electric Auto-Lite Co., Ohio (a,b,c,g)
Electric Materials Co., Pa (b)
Electronic Parts Mfg. Co., Inc., NJ (c,f,g)
Elgin National Watch Co., Abrasives Div., Ill
Elsby, J.S., Inc., Wis (a,b,f,g)
Enoch Mfg. Co., Ore (a,b,c,e,g,j)
Essential Bar Products Co., Mich (a, b,f,g)
Eureka Electric Products Inc., Pa (a, b)
Everard Tap & Die Corp., NY (a,b,c, f,g)
Fairchild Screw Products, Inc., Conn (a,b,f,g)
Falls Machine Co., Ohio (a,b,g)
Federal Screw Works, Mich (a,b,f,g)
Femco Mfg. Co., Inc., Mich (g)
Fischer Special Mfg. Co., Ohio (a,b)
Fordsell Machine Products Co., Mich (a,b,f,g)
Frisby, R.J. Mfg. Co., Ill (a,b,g)
G & G Mfg. Co., Ill (a,b,f,g)
G & Z Automatic Products Co., Mich (a,b,g)
Gantner Screw Products Co., Inc., Ohio (a,b,f,g)
Gar Precision Parts, Inc., Conn
General Engineering Works, Ill (a,b,f, g)
General Findings & Supply Co., Industrial Div., Mass (a,b,c,f,g)
General Screw Products Corp., NY (a, b,f,g)
Grass, M.J. Machine Products Co., NY (a,b,f,g)
Greer Stop Nut Co., Ill (a,b,c,e,f,g,h, j)
Gregg Metal Products Inc., Wis (a,b, f,g)
Grip Nut Co., Ind
Gross Willard N., Inc., NJ (a,b,f,g)
H & H Screw Products Mfg. Co., RI (a,b,f,g)
H & K Machine Service Co., Inc., Mo (a,b,g)
Haber, Ill (a,b,c,f)
Hack, J.H. Mfg. Co., Mich (a,b,f,g)
Hardy Mfg. Corp., Ind (a,b,g)
Harvey Aluminum, Calif (a,g)
Harvin & Co., NJ (a,b,f,g)
Harwood Screw Products, Inc., Ohio (a,b,g)
Held, O.P., Inc., NY (a,b,c,g)
Heller, A.B. Screw Products, Inc., Mich (a,b,g)
Henefelt Precision Products, Inc., Fla (a,b,f,g)
Hercules Fastener Co., Ill (a,c,f,g,j)
Herker Screw Products, Inc., Wis (a,b, g)
Herman Machine & Tool Co., Ohio (a, b,f,g)
Hershey Metal Products, Inc., Conn (a,b,f,g,h)
Holt Products Co., Mich (a,g)
Hoofer Mfg. Co., Ill (a,c)
Hoyt, Charles D. Co., Inc., Ind (a, b,f,g)
Huck Mfg. Co., Mich (a)
Hudson Screw Machine Products Co., Ill (a,b,c,e,f,g,h,j)
Hunt Screw & Mfg. Co., Ill (a,b,f,g,h)
Huron Automatic Screw Co., Mich (a,b,g)
Hy-Level Screw Products Co., Ohio (a, b,g)
Ideal Metal Products Co., Ill (a,b,f,g)
Imsande Screw Products Co., Ohio (a, b)
Industrial Precision Products, Ill (a,b, c)
Inland Mfg. Co., Neb (a,b,c,d,e,f,g,h,j)
Instrument Parts Corp., NY (a,b,c,f,g)
Instrument Specialties Co., Inc., NJ (b)
Jaques Co., Mass (a,b,e,f,g,h)
Jolens Metal Products Co., NJ (a,b,f, g)
Jordan Machine Products, Inc., Mich (a,b,f,g)
Kay-Bee Machine Products Co., Wis (a,b,g)
Kennedy Automatic Products, Inc., Mich (a,b,g)
Kenosha Automatic Products Co., Wis (a,b,g)
Kerr-Lakeside Industries, Inc., Ohio (a,b,f,g)
Klincher Locknut Corp., Ind (f,g)
Koehler Mfg. Co., Mass (c)
Kohn Engineering Corp., Mich (a,b,c, f,g,h)
Kramer, C.P. Co., Ill (a,f,g)
Lake Mfg. Corp., Conn (a,b,g)
Lamson Products Co., Wash (a,b,d,e, f,g,j)
Lattner Bros. Machining Co., Mich (a, b,f,g)
Latwaitis, Ernest A., NY (a,b,f,g)
Lawrenceville Screw Co., Pa (a,b,f,g)
Lincoln Machine Parts Corp., NY (a, b,f,g,h)
Lincoln Mfg. Co., Inc., Ill (a,b,f,g)
Linden & Co., Inc., RI (a,b,c,g)
Livingston-Tyler Products, Ohio (a,b, e,g)
Locke Machine Co., Ohio (a,b,e,f,g)
Loeffler, J.M. Machine Co., Pa (a,b,c)
Lorain Automatic Screw Machine Co., Inc., Ohio (a,b,g)
Lubenow, Arthur Co., Wis (a,b,f,g)
Lundberg Screw Products Co., Mich (a, b,g)
Lyndon Machine Products Co., Inc., Mich (a,b,g)

M & S Mfg. Co., Mich (a,b,g)
Machine Products Corp., Ohio (a,b,c,d,e,f,g,h,j)
Machinery Products Co. of Lancaster, Pa (a,b,f,g)
Machinery Products Corp., Ill (a,b,f,g)
Mac-It Parts Co., Pa (b,f,g)
Main Screw Machine Products, Inc., Conn (a,b,g)
Mantel Screw Products Co., Wis (a,b,f,g,h)
Marquette Metal Products Co., Ohio (a,b,f,g)
Masco Screw Products Co., Mich (a,b,f,g)
Massachusetts Screw Mfg. Co., Mass (a,b,f,g)
Maynard Mfg. Co., Mich (a,b,f,g,h)
McKinney Mfg. Co., Pa (a,b,e,f,g)
McLanahan & Stone Corp., Pa (c,g)
McMahon Bros. Machine Works, Inc., Ill (a,b,f,g,h)
Meaden Screw Products Co., Ill (a,b,f,g)
Measuregraph Co., Mo (a,b,f,g,h)
Mechanical Art Works, Inc., NJ (a,b,f,g)
Meier Screw Products & Mfg. Co., Mich (a,b,c,e,f,g)
Merit Screw Machine Products Co., Ill (a,b,f,g,h)
Merit Specialties Co., Inc., Mo (a,b,e,f,g)
Merz Machine & Tool Works, Ind (a,b,g)
Micro Products Corp., Mo (a,g)
Mid-West Screw Products Co., Mo (a,b,c,g)
Midwest Screw Products, Inc., Ohio (a,b,f,g,h)
Milford Automatics, Inc., Conn (a,b,g)
Milled Screw Products, Co., Ill (a,b,f,g)
Millers' Brass Fitting Co., Inc., NY (a,b,f,g)
Milwaukee Machine Products Co., Wis (a,b,g)
Milwaukee Stamping Co., Wis (a,g)
Mitchell & Scott Machine Co., Inc., Ind (a,b,f,g)
Modern Screw Products Co., Mo (b,f,g)
Monarch Tool & Mfg. Co., Ky (g)
Moody Machine Products Co., Inc., RI (a,b,c,f,g)
Moore, George W., Inc., Mass (a,b,g)
Mueller Brass Co., Mich (a,b,f)—Ad p 404
Mueller Machine Products Inc., Wis (a,b,c,d,e,f,g,j)
Napoleon Products Co., Ohio (a,g)
National Acme Co., Ohio (a,b,f,g)
National Lead Co., NY (a)
National Screw & Mfg. Co., Ohio (b,f,g)
New Britain Machine Co., Conn (a,b,g)
New Haven Screw Machine Products, Inc., Conn (a,b,f,g,h,j)
Newtown Mfg. Co., Conn (a,b,f,g,h)
Nicoud Mfg. Co., Ill (a,b,f,g)
Noera Mfg. Co., Conn (a,b,g)
Nolte Screw Machine Products, Inc., Ohio (a,b,c,f,g)
Northwest Automatic Products Corp., Minn (a,b,f,g)
Nutmeg Screw Machine Products Co., Conn (a,b,f,g)
Nylok Corp., NJ (a,b,c,e,g,h)
Ohio Metal Products Co., Ohio (a,b,f,g,h)
Ohio Screw Products, Inc., Ohio (a,b,f,g)
Olderman Mfg. Corp., Conn (a,b)
Olson Mfg. Co., Mass (a,b,f,g)
Ostby & Barton Co., Flightex Fabrics, Inc., RI (a,b,f,g)
Ottawa Steel Products, Inc., Mich (g)
Pabst Engineering Equipment Co., Inc., NJ (a,b,c,e,f,g,h,j)
Pacific Screw Products Co., Calif (a,b,f,g)
Pan-American Metal Products Co., Inc., Fla (a,b,f,g)
Parker & Harper Mfg. Co., Mass (a,b,f,g)
Peck Spring Co., Conn (a,b,c,f,g)
Peerless Automatic Machine Co., Ohio (a,b,c,g)
Peerless Industries, Inc., Mich (a,b,g)
Peerless Products Industries, Ill (a,b,g)
Perry Fay Co., Ohio (a,b,g)
Philadelphia Enameling Works Inc., Pa (a,b,g)
Phillips, F.C., Inc., Mass (b,f,g)
Phillips Bros. Screw Products Co., Mich (b,f,g,h)
Piper Tool Co., Inc., Mich (g)
Pohlman, R.L. Co., Mo (a,b,g)
Polyphase Machine Co., NY (a,b,f,g,h)
Precision Machine Co., Ind (a,b,g)
Precision Piece Parts, Inc., Ind (g)
Precision Screw Products Co., Inc., Calif (a,b,f,g)
Progressive Service Co., Mo (a,b,e,f,g)
Racine Screw Co., Wis (a,b,f,g)
Rainier Metal Products Co., Ill (a,b,g)
Rasco-Veeder Co., Ill (a,b,f,g)
Ravenswood Machine Corp., Ill (a,b,f,g)
Red Devil Mfg. Co., Ill (a,b,c,d,e,f,g,h,j)
Redmer Air Devices, Ala (a,b,c,f,g)
Reliable Screw Machine Products, Ill (a,b,f,g,h)
Remler Co., Ltd., Calif (a,b,f,g)
Rex Products Co., Ohio (a,b,f,g)
Richmond Mfg. Co., Tex (a,b,f,g)
Rockwell Engineering Co., Ill (a,b,c,g)
Rosan Inc., Calif (a,g)
S & S Mfg. Co., NJ (a,b,c,e,f,g,h)
Sargent & Greenleaf, Inc., NY (a,b,g)
Scovill Mfg. Co., Mill Products Div., Conn (a,b)
Seltzer, George H. & Co., Pa (g)
Sheller Mfg. Corp., Mich (g)
Sinclair Co., Mass (a,b,g)
Spencer Nahm Co., Calif (a,b,f,g)
Spencer's Sons, I.S., Inc., Conn (a,b,g)
Standard Pressed Steel Co., Pa (a,b,c,e,f,g,h)
Standard Screw Products Co., Calif (a,b,g)
Star Heel Plate Co., Inc., NJ (g)
Steel Heddle Mfg. Co., Pa (a,b,c,e,f,g,h,j)
Steel Industries, Inc., Ind (a,b,g)
Steinen, Wm. Mfg. Co., NJ (a,b,c,f,g,h)
Thompson-Bremer & Co., Ill (a,b,c,f,g,h)
Thompson Products, Inc., Ohio (h)
Titan Metal Mfg. Co., Pa (a,b)
Tompkins Products, Mich (a,b,c,d,f,g,j)
Torrington Co., Conn (a,b,f,g)
Trigon Specialties Corp., Ind (a,b,c,d,e,f,g,h,j)
Ullmann, Inc., Wis (a,b,c,e,f,g,h)
Union Screw & Mfg. Co., Pa (a,b,g)
United Screw & Bolt Corp., Ill (a,b,g)
United Shoe Machinery Corp., Mass (a,b,c,f,g)
Unity Machine & Tool Corp., Pa (a,g)
Vanamatic Co., Ohio (a,b,g)
Wagner Specialty Co., Wis (a,b,c,g,j)
Wall, P. Mfg. Co., Pa (a,b,c,g)
Waldman, Joseph & Sons, Epoxy Products Div., NJ (a,b,c,f,g)
Walrod Machine Products, Ore (a,b,g)
Ward, H.H. Co., Pa (a,b,c,f,g,j)
Waterman Industries, Inc., Calif (a,b)
Weatherhead Co., Ind (a,b,c,d,e,f,g,h,j)
Weber-Knapp Co., NY (a)
Wedler Bros., Inc., Ohio (a,b,f,g)
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (a,b,c,f,g)
Western Machine Co., Wis (a,b,c,f,g,j)
Wirth, Carl & Son, Inc., NY (a,b,c,d,e,f,g,h,j)
Worth Co., Wis (a,b,c,g)
Wright, Albert Screw Machine Products, Calif (a,b,f,g)
Wuest Bros., Inc., Ky (a,b,c,f,g)
Zeller Corp., Ohio (g)

Selenium

American Metal Climax, Inc., NY (aa)
American Nickel Alloy Mfg. Corp., NY (aa)
American Smelting & Refining Co., NY (q,aa)
Anaconda Co., NY (aa)
Belmont Smelting & Refining Works, Inc., NY (aa)
Cerro Sales Corp., Sub. of Cerro Corp., NY (aa)—Ad p 154
Federated Metals Div., American Smelting & Refining Co., NY (aa)
Hardy, Charles, Inc., NY (aa)
Hommel, O. Co., Pa (aa)
Kawecki Chemical Co., NY (aa)
McGean Chemical Co., Ohio (aa)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Phelps Dodge Refining Corp., NY (aa)

Sheet

(see specific material)

Sheet Formed Plastics Parts

(see Moldings, Sheet)

Sherardized Coatings

(see Diffusion Coatings)

Silicides

(see Refractories)

Silicon

American Nickel Alloy Mfg. Corp., NY (w,aa)
Belmont Smelting & Refining Works, Inc., NY (aa)
du Pont de Nemours, E. I. & Co., Inc., Del (w)
Glidden Co., Chemical Divs.,
Metals Dept., Ind., (aa)
Metals Dept., Pa (aa)
Hardy, Charles, Inc., NY (aa)
Lavin, R. & Sons, Inc., Ill (w)
Monsanto Chemical Co., Inorganic Chemicals Div., Mo (q,w,bb)
National Electric Div., H.K. Porter Co., Pa (ff)
National-Standard Co., Mich (ff)
National-U.S. Radiator Corp., Plastic Metals Div., NY (aa)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Sylvania Electric Products, Inc., Chemical & Metallurgical Div., Pa (w,bb,ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Utica General Jobbing Foundry, Inc., NY (aa)
Vanadium Corp. of America, NY (w)

Silicon Bronze

(see Copper)

Silicone Plastics

Adhesive Products Corp., NY (x)
Alpha Wire Corp., NY (ee)
Belko Corp., Md (y)
Bisonite Co., Inc., NY (y)
Colonial Kolonite Co., Ill (bb,cc,ee)
Comco Plastics, Inc., NY (bb,cc,dd,ee)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Cordo Chemical Corp., Conn (x,y)
Curbell, Inc., NY (bb,cc,dd,ee)
Dodge Fibers Corp., NY (s)
Dow Corning Corp., Mich (p,u,x,y)
Dyna-Therm Chemical Corp., Calif (p)
Electrofilm, Inc., Calif (t)
Emerson & Cuming, Inc., Mass (u)
Flexible Tubing Corp., Conn (ee)
Formica Corp., Sub. of American Cyanamid Co., Ohio (cc,ee)
Foss Mfg. Co., Id
Furane Plastics, Inc., Calif (x)
General Electric Co., Laminated Products Dept., Ohio (cc)
General Electric Co., Silicone Products Dept., NY (p,u,x,y)
General Gasket, Inc., Conn (cc)
Glass Reinforced Plastics Corp., Ohio (bb,ee)
Hadbar, Inc., Calif (u,y,bb,cc,dd,ee)
Hall, C.P. Co., Ohio (p)
Hewitt-Robins, Inc., Conn (u,cc,ee)
Insulation Mfrs. Corp., Ill (p,y,bb,cc,dd,ee)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Kurz Kasch, Inc., Ohio (y)
Maloney, F.H. Co., Tex (y)
Mesa Plastics Co., Calif (p,y,bb,cc)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (bb,cc)
Narmco Industries, Inc., Narmco Materials Div., Calif (x)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
National Vulcanized Fibre Co., Del (bb,cc,dd,ee)
Panelyte Div., St. Regis Paper Co., NJ (x,bb,cc,dd,ee)
Parker, Stearns & Co., Inc., NY (bb, cc,dd,ee)
Pawling Rubber Corp., NY (bb,dd,ee)
Philrus Products Co., NJ (bb,cc,dd,ee)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Prince Rubber & Plastics Co., Inc., NY (bb,cc,ee)
Products Research Co., Calif (y)
Raybestos-Manhattan, Inc., NJ (bb, cc,dd)
Raybestos-Manhattan, Inc., Plastic Products Div., Pa (x)
Rogers Corp., Conn (u,y,bb,cc,dd)
Staver Co., Inc., NY (cc,dd)
Swedlow Inc., Calif (cc)
Synthane Corp., Pa (bb,cc,dd,ee)
Tanner Engineering Co., Calif (ee)
Taylor Fibre Co., Pa (cc,dd,ee)
Toyad Corp., Pa (u)
Union Carbide Corp., Silicones Div., NY (p,t,u,x,y)
U.S. Polymeric Chemicals, Inc., Conn (s,y)
Varflex Corp., NY (ee)
Western Felt Works, Ill (cc)
William Brand-Rex Div., American Enka Corp., Mass (ee)

Silicone Rubber

Adhesive Products Corp., NY (x)
Alpha Wire Corp., NY (ee)
Armstrong Cork Co., Pa (bb,cc,dd)
Belko Corp., Md (y)
Bond International, Inc., Mich (y,ee)
Capac Mfg. Corp., Mich (y)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Ill (p)
Coast Pro-Seal & Mfg. Co., Calif (y)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio (y)—Ad p 416
Connecticut Hard Rubber Co., Conn (s,u,y,bb,cc,dd)
Continental Rubber Works, Pa (bb, cc,dd,ee)
Continental-Diamond Fibre Corp., Del (cc,dd)
Dayton Rubber Co., Ohio (y,bb,cc,dd, ee)
Delta Plastics Co., NJ (bb,cc,dd)
Dow Corning Corp., Mich (p,u,x,y)
Dyna-Therm Chemical Corp., Calif (p)
Flexible Tubing Corp., Conn (ee)
Garlock Packing Co., NY (y,bb,cc,dd, ee)
General Electric Co., Chemical & Metallurgical Div., Ill (cc,dd,ee)
General Electric Co., Plastics Dept., Ill (p,y,bb,cc,dd,ee)
General Electric Co., Silicone Products Dept., NY (p,u,y)
Goshen Rubber Co., Inc., Ind (y)
Hadbar, Inc., Calif (y,bb,cc,dd,ee)
Haveg Industries, Inc., Del (bb,cc,ee)
Hewitt-Robins, Inc., Conn (cc,ee)
Insulation Mfrs. Corp., Ill (cc,dd)
Maloney, F.H. Co., Tex (y)
Mechanical Rubber Products Co., NY (t,u,bb,cc,dd)
Micarta Div., Westinghouse Electric Corp., SC (cc)
Mid-States Rubber Products, Inc., Ind (y)
Minnesota Rubber Co., Minn (ee)
Moxness Products, Inc., Wis (bb,cc, dd,ee)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Paeco Rubber Co., Inc., Ohio (y, dd, ee)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (y)
Pawling Rubber Corp., NY (bb,dd,ee)
Permacel, NJ (t,u,bb,cc)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (t)
Prince Rubber & Plastics Co., Inc., NY (bb,cc,ee)
Products Research Co., Calif (y)
Raybestos-Manhattan, Inc., NJ (bb, cc,dd)
Raybestos-Manhattan, Inc., Plastic Products Div., Pa (x)
Rayclad Tubes, Inc., Calif (ee)
Rogers Corp., Conn (u,y,cc,dd)—Ad pp 270-271
Roth Rubber Co., Ill (cc)
Sperry Rubber & Plastics Co., Ind (dd,ee)
Stockwell Rubber Co., Inc., Pa (u,y, bb,cc,dd)
Swedlow, Inc., Calif (cc)
Taunton Div., Haveg Industries Inc., Mass (u,bb,cc,dd,ee)
Toyad Corp., Pa (u)
Trostel, Albert Packing, Ltd., Wis (y)
Union Carbide Corp., Silicones Div., NY (p,y,cc,dd)—Ad p 261
U.S. Polymeric Chemicals, Inc., Conn (s)
U.S. Stoneware Co., Ohio (y)
Varflex Corp., NY (ee)
Vulcan Div., Reeves Bros., Inc., NY (p,y,cc)
Western Felt Works, Ill (y,cc,dd,ee)
William Brand-Rex Div., American Enka Corp., Mass (ee)
Williams-Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Silver and Its Alloys

Alloy Metal Powders, Inc., Iowa (aa)
Alpha Metals Inc., NJ (n,o,q,bb,cc,dd)
American Metal Climax, Inc., NY (w,aa)
American Platinum & Silver Div., Engelhard Industries, Inc., NY (n, o,q,v,w,z,aa,bb,cc,dd,ff)
American Products Corp., Ill (dd,ff)
American Silver Co., NY (v,dd,ee,ff)
American Smelting & Refining Co., NY (n,o,q,bb,ee)
Anaconda Co., NY (o)
Baker & Co., Inc., NJ (n,o,v,w,z,aa, bb,cc,dd)
Belmont Smelting & Refining Works, Inc., NY (o,dd,ff)
Bunker Hill Co., Sales & Fabrication Div., Calif (o)
Cerro Sales Corp., Sub. of Cerro Corp., NY (o,w)
Composite Industrial Metals, Inc., RI (n)
Designers Metal Corp., Ill (cc)
Division Lead Co., Ill (ff)
Eastern Smelting & Refining Corp., Mass (n,o,v,w,aa,bb,cc,dd,ee,ff)
Eynon-Dakin Co., Mich (ee)
Federated Metals Div., American Smelting & Refining Co., NY (n)
Fox Products Co., Pa (n)
Fulton Gold Refiners Corp., NY (n,o, q,v,w,aa,bb,cc,dd)
Gibson Electric Sales Corp., Pa (aa, bb,dd,ff)
Goldsmith Bros. Div., National Lead Co., Ill (n,o,v,w,z,aa,bb,cc,dd,ff)
Handy & Harman, NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)—Ad p 151
Hanovia Chemical & Mfg. Co., NJ (aa)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (ff)
Hommel, O. Co., Pa
Horton-Angell Co., Mass (n,o,bb,cc,dd, ee,ff)
Hudsar, Inc., NJ (w)
Kwikset Powdered Metal Products, Calif (aa)
Leach & Garner Co., Industrial Div., Mass (n,o,q,v,z,bb,cc,dd)
Lucas-Milhaupt Engineering Co., Wis (dd,ff)
Makepeace, D.E. Div., Engelhard Industries Inc., Mass (n,o,v,z,aa,bb,dd, ee,ff)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metals Disintegrating Co., Inc., NJ (aa)
Metz Refining Co., NJ (n,o,q,z,aa,bb, cc,dd,ee)
Minimax Co., Ill (aa)
Nesor Alloy Products Co., NJ (dd,ff)
Ney, J.M. Co., Industrial Div., Conn (v,z,bb,cc,dd,ff)
Norwalk Powdered Metals, Inc., Conn (aa)
Peerless Roll Leaf Co., Div. of Howe Sound Co., NJ (v,dd)
Reade Mfg. Co., Inc., NJ (aa)
Republic Metals Co., Inc., NY (o,w)
Rigidized Metals Corp., NY (cc,dd)
Rotometals, Calif (dd,ff)
Sel-Rex Corp., NJ (n,aa)
Sherwatt Equipment & Mfg. Co., Inc., NY (ff)
Texas Instruments, Inc., Metals & Controls Div., Mass (n,o,q,v,w,z,aa, bb,cc,dd,ee,ff)
Ullmann, Inc., Wis (o,ee)
United Wire & Supply Corp., RI (ff)
Vanadium-Alloys Steel Co., Pa (aa)
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif (aa, cc,dd,ff)
Wildberg Bros. Smelting & Refining Co., Calif (n,o,v,w,z,aa,bb,cc,dd,ff)
Williams Gold Refining Co., Inc., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Wilson, H.A. Div., Engelhard Industries, Inc., NJ (cc)

Slush Moldings

(see Moldings)

Solders

Abalon Precision Mfg. Corp., NY
All-State Welding Alloys Co., Inc., NY
Alofs Mfg. Co., Mich
American Emblem Co., Inc., NY
American Metal Climax, Inc., NY
American Products Corp., Ill
American Smelting & Refining Co., NY
Anchor Metal Co., Inc., NY
Belmont Smelting & Refining Works, Inc., NY
Bishop, J. & Co. Platinum Works, Pa
Cerro Sales Corp., Sub. of Cerro Corp., NY
Chemical Development Corp., Mass
Composite Industrial Metals, Inc., RI
Consolidated Fruit Jar Co., NJ
Division Lead Co., Ill
Dyna-Therm Chemical Corp., Calif
Empire Metal Co., NY
Eutectic Welding Alloys Corp., NY
Falstrom Co., NJ
Farrelloy Co., Pa
General Findings & Supply Co., Industrial Div., Mass
Hayden Wire Works, Inc., Mass
Ideal Can Co., Mass
Indium Corp. of America, NY —Ad p 154
Kenmore Machine Products, Inc., NY
Kester Solder Co., Ill
Kling Metal Spinning & Stamping Co., NY
L. & R. Mfg. Co., NJ
Langsenkamp, F.H. Co., Ind
Lucas-Milhaupt Engineering Co., Wis
Lundquist Tool & Mfg. Co., Inc., Mass
Magnesium Products of Milwaukee, Inc., Wis
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass
Marquette Mfg. Co. Div., Marquette Corp., Minn
Meier Brass & Aluminum Co., Mich
Metal Goods Corp., Mo
Metallizing Co. of Los Angeles, Inc., Calif
Midwest Stamping & Mfg. Co., Ohio
National Lead Co., NY
Ney, J.M. Co., Conn
Presswork, Inc., Mich
Ren Plastics, Inc., Mich
Republic Metals Co., Inc., NY
Reynolds Aluminum Supply Co., Ga
Rockwell Engineering Co., Ill
Rotometals, Calif
Ruby Chemical Co., Ohio
Schramm Fiberglass Products, Inc., Ill
Trenton Pipe Nipple Co., NJ
United Refining & Smelting Co., Ill
United Wire & Supply Corp., RI
Waterman Industries, Inc., Calif
Wayne Chemical Products Co., Mich
West Haven Foundry Co., Conn
Whitehead Metal Products Co., Inc., NY
Wildberg Bros. Smelting & Refining Co., Calif
Williams Gold Refining Co., Inc., NY

Spinnings

Ace Metal Spinning, Ill (a,b,c,d,e,f, g,h,j)
Acme Metal Spinning, Inc., Minn (a b,c,d,e,f,g,h,j)
Aluminum Co. of America, Pa (a)
Aluminum Goods Mfg., Wis (a)
Aluminum Specialty Co., Wis (a)
American Aluminum Co., NJ (a,b)
Anchor Metal Spinning Co., Ohio (a, b,c,d,e,f,g,h,j)
Bartlett-Thompson Co. Inc., Mass (a, b,f,g)
Bergfels, William & Co., NJ (a,b,c, f,g,j)
Biersach & Niedermeyer Co., Wis (a,g)
Broadway Mfg. Co., Wis (a,b,c,f,g)
Brooks & Perkins, Inc., Mich (a,e,h)
Clover Industries, Inc., NY (a)
Commerical Shearing & Stamping Co., Ohio (a,b,e,f,g)
Craft Mfg. Co., Ill (a,b,c,d,f,g)
Craft Metal Spinning Co., Ill (a,b,f,g)
Cyril Bath Co., Ohio (a,g)
Dahlin, C.A. Co., Ill (a,b,e,f,g,h,j)
Dow Chemical Co., Mich (e)
Emerson-Sack-Warner Corp., Mass (a, b,c,e,f,g,h,j)
Garco Mfg. Co., Inc., Ill (a,b,e,f,g,h, j)
General Alloys Co., Mass (a,b,f)
Greene, G.G. Corp., Pa (a,g)
H & H Tube & Mfg. Co., Mich (b)
Hardy Mfg. Corp., Ind (a,g)
Kelsey-Hayes Co., Mich (g)
Kenmore Machine Products, Inc., NY (b)
Kling Metal Spinning & Stamping Co., NY (a,b,c,d,e,f,g,j)
Lukens Steel Co., Pa (a,b,e,f,g,h)
Magline, Inc., Mich (e)
Magnesium Products of Milwaukee, Inc., Wis (a,e)
Manufacturers Service, Inc., Ohio (a, b,g)
Mirro Aluminum Co., Wis (a)
Morse, Fred W. Co., RI (a,b,c,g,j)
Muncie Metal Spinning, Inc., Ind (a, b,g)
Murray, A.B. Co., Inc., NJ (a,b,f,g)
Murray Tube Works, Inc., NJ (a,b,g)
Pabst Engineering Equipment Co., Inc., NJ (a,b,c,e,f,g)
Perrin, Edward C. Co., NJ (a,b,g)
Phoenix Products Co., Wis (a,b,c,d,e, f,g,h,j)
Phoenix Steel Corp., NY (g)
Precision Metal Spinning Co., Mich (a,b,c,e,f,g)
Premier Metal Works, Inc., Ill (a,h,g)
Regal Ware, Inc., Wis (a,b,g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (b)
Reynolds Metals Co., Va (a)
Rockwell Engineering Co., Ill (a,b,c,g)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
Schrader, J. Co., Ohio (a,b,c,d,e,f,g,j)
Seattle Boiler Works, Inc., Wash (a,g)
Smith-Victor Corp., Ind (a)
Spincraft, Inc., Wis (a,b,c,d,e,f,g,h,j)
Stainless Metals, Inc., NY (c,f,h)
Stirrup Metal Products Corp., NJ (a, b,g)
Teiner, Roland Co., Inc., Mass (a, b,e,f,g,h)

Toledo Stamping & Mfg. Co., Ohio (a,b,g,h)
Torngren, C.W. Co., Inc., Mass (a,b,c,e,f,g,h,j)
Ward, H.H. Co., Pa (a,b)

Sprayed Coatings

(see Metallized Coatings)

Stampings, Punchings

(see also Drawn, Pressed Parts)

Abalon Precision Mfg. Corp., NY (a,b,c,g)
Acme Mfg. & Gasket Co., Pa (a,b,f,g)
Acme Metal Spinning, Inc., Minn (a,b,c,e,f,g,j)
Acme Stamping & Wire Forming Co., Pa (a,b,g)
Acorn Sheet Metal Mfg. Co., Inc., Ill (a,g)
Acro Metal Stamping Co., Wis (a,b,f,g)
Adams, I.G. Metalware Co., Mo (a,b,c,e,f,g,j)
Advance Stamping Co., Mich (a,b,c,d,f,g,j)
Aerolite Electronics Corp., NJ (a,b,c,g)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (g)
All-Form Metal Products Co., Ohio (a,b,c,d,e,f,g,j)
Allied Products Corp., Mich (a,g)
Alloy Products Corp., Wis (a,f,g,h)
Almco Steel Products Corp., Ind (a,b,g)
Alofs Mfg. Co., Mich (a,b,g)
Alox Mfg. Co., Mo (a,b,c,f,g)
Alpha Metals, Inc., NJ (a,g)
Aluminum Co. of America, Pa (a)
Aluminum Goods Mfg., Wis (a)
Aluminum Specialty Co., Wis (a,g)
American Aluminum Co., NJ (a,b)
American Emblem Co., Inc., NY (a,b,g)
American Mfg. Co., Tenn (a,g)
American Sanitary Mfg. Co., Ill
American Sheet Metal Works, Inc., Conn (a,b,g)
American Silver Co., NY (a,b,e,f,g)
American Stamping Co., Ohio (a,b,g)
Anaconda American Brass Co., NY (a,b,g)
Anchor Metal Spinning Co., Ohio (a,b,c,d,e,f,g,h,j)
Anderson, O.L. Co., Inc., Mich (a,b,c,e,f,g,h,j)
Anderson-Bolling Mfg. Co. Mich (a,g)
Anthes Div., Gleason Corp., Iowa (a,g)
Anti-Corrosive Metal Products Co., Inc., NY (g)
Armor Metal Products Co., Ohio (a,g)
Art Wire & Stamping Co., NJ (a,b,c,d,f,g)
Arvin Industries, Inc., Ind (a,g)

Ashtabula Mfg. Co., Ohio (g)
Associated Spring Corp., Wallace Barnes Steel Div., Conn (g)
Atkins Saw Div., Borg-Warner Corp., Ind (g)
Atlas Metal Parts Co., Wis (a,b,c,g)
Auburn Mfg. Co., Conn (a,b,c,d,e,f,g)—Ad p 318
Auel Industries, Pa (a,b,f,g)
Auld, D.L. Co., Ohio (a,b,c)
Autel Electronics Co., Precision Machine & Welding Div., NJ (a,b,c,e,g,h)
Automotive Rubber Co., Inc., Mich (f,g)
Backus Novelty Co., Pa (a,b,c,f,g)
Barclay Mfg. Co., Ind (c)
Bartlett-Thompson Co., Inc., Mass (a,b,f,g)
Bay State Stamping Co., Mass (a,b,g)
Beacon Metal Mfg. Co., NY (a,b,c,d,e,f,g,h,j)
Behringer Metal Works, Inc., NJ (a,b,c,g)
Belmet Products, Inc., NY (a,b,g)
Benjamin Electric Mfg. Co., Ill (a,b,g)
Bennett Mfg. Co., NY (a,b,e,g)
Bethlehem Steel Co., Pa (g)
Biddle Screw Machine Products Co., Ind (a,b,c,d,e,f,g,h)
Biersach & Niedermeyer Co., Wis (a,b,c,g)
Bingham Herbrand Corp., Bingham Stamping Div., Ohio (g)
Blacher Bros., Inc., RI (a,b,g)
Blaco Mfg. Co., Ohio (b,g)
Blickman, S., Inc., NJ (a,b,c,g)
Boots Aircraft Nut Corp., Conn (g)
Borg-Warner Corp., Ingersoll Products Div., Ill (g)
Braun, H. Tool & Instrument Co., Inc., NJ (a,b,f,g)
Brewer-Titchener Corp., NY (a,g)
Brooks & Perkins, Inc., Mich (a,e,h)
Burgess-Norton Mfg. Co., Ill (c)
Butler Mfg. Co., Mo (a,g)
Carbo Tool & Die Co., Ohio (c)
Carroll Pressed Metal, Inc., Mass (a,b,f,g)
Cartwright, R. Tube Products Co., Mich (a,b,g)
Clendenin Bros., Inc., Md (a,b)
Cleveland Metal Products Co., Ohio (a,b,c,f,g)
Cleveland Pressed Products Corp., Ohio (a,b,g)
Clover Industries, Inc., NY (a)
Cly-Del Mfg. Co., Inc., Conn (a,b,f,g,j)
Columbia Metal Stamping Co., Ohio (a,g)
Columbian Steel Tank Co., Mo (g)
Columbus Dental Mfg. Co., Ohio (a,b,c,g)
Columbus Jack Corp., Ohio (a,c,g)
Comerford Mfg. Co., Inc., Conn (a,b,c,e,f,g,j)
Commercial Shearing & Stamping Co., Ohio (a,b,f,g)
Composite Industrial Metals, Inc., RI (a,b,c,d,e,f,g,h,j)

Consolidated Fruit Jar Co., NJ (a,b,c,d,g,j)
Cooley, W.J. & Co., Tenn (a,b,g)
Craft Mfg. Co., Ill (a,b,c,d,f,g)
Croname Inc., Ill (a,b,f,g,j)
Crosby Co., NY (a,b,g)
Crown Metal Co., Wis (d)
Cuyahoga Stamping Co., Ohio (a,b,g)
Cyril Bath Co., Ohio (a,e,f,g,h)
Dahlin, C.A. Co., Ill (a,b,e,f,g,j)
Dana Corp., Auburn Div., Ind (g)
Danby Mfg. Co., Mich (a,b,g)
Dare Products, Inc., Mich (g)
Day Co., Minn (a,g)
Dayton Rogers Mfg. Co., Minn (a,b,g)
Dearborn Stamping Co., Mich (g)
Defiance Metal Products Co., Ohio (a,g)
Defiance Stamping Co., Ohio (g)
Detroit Stamping Co., Mich (a,b,g)
Diamond Mfg. Co., Pa (a,b,f,g)
Dirilyte Co. of America, Inc., Ind (a,b)
Division Lead Co., Ill (d)
Dixon Corp., RI (k)
Doehler-Jarvis Div., National Lead Co. Ohio (a)
Dolin Metal Products, Inc., NY (g)
Dow Chemical Co., Mich (a,e)
Dudek & Bock Spring Mfg. Co., Ill (a,g)
Duplex Mfg. Corp., Ark (a,g)
Duplican Co., Inc., Mass (a,b,c,e,f,g,h,j)
Earley, Sam C. Corp., Ohio (a,b,g)
Eastern Tool & Mfg. Co., NJ (a,b,c,g)
Eastern Tool & Stamping Co., Inc., Mass (a,b,c)
Eby, Hugh H. Co., Pa (a,b,f)
Electric Auto-Lite Co., Ohio (a,b,g)
Electric Materials Co., Pa (b)
Electro-Chemical Engineering Co., NY (a,b,g)
Electronic Parts Mfg. Co., NJ (c,f,g)
Elgin National Watch Co., Abrasives Div., Ill
Ellicott-Brandt, Inc., Md (a,b,e,f,g)
Ellwood City Iron & Wire Co., Pa (c)
Emerson-Sack-Warner Corp., Mass (a,b,c,f,g)
Empire Spring Co., Ohio (a,b,f,g)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (g)
Enamel Products Co., Ohio (a,c)
Evans, George Corp., Ill (a)
Eureka Electric Products Inc., Pa (a,b)
Everard Tap & Die Corp., NY (a,b,f,g)
Fabristeel Products, Inc., Mich (g)
Falstrom Co., NJ (a,b,e,g)
Farwell Metal Fabricating, Minn (a,b,e,f,g)
Federal Tool Corp., Ill (a,b,c,g)
Federal Tool & Mfg. Co., Minn (a,b,c,f,g)
Figley Die & Stamping Co., Ohio (a,b,g)
FitzSimons Mfg. Co., Mich (a,b,g)
Fletcher Enamel Co., W.Va (a,b,c,d,e,f,g)

Follansbee Steel Corp., Sheet Metal Specialty Div., W.Va (a,b,g)
Forg, Peter Mfg. Co., Mass (a,b,c,g)
Fox Co., Ohio (a,b,c,g)
Fox Products Co., Pa (c)
Fryling Mfg. Co., Pa (a,b,f,g,j)
Garco Mfg. Co., Inc., Ill (a,b,c,e,f,g,h,j)
Gary Steel Products Corp., Va (a,g)
General Alloys Co., Mass (a,b,f)
General Chain & Mfg. Corp., Ohio (g)
General Extrusions, Inc., Ohio (a)
General Findings & Supply Co., Industrial Div., Mass (a,b,c,f,g)
General Gasket, Inc., Conn (a,b,c,d,g)
Gerstenslage Co., Ohio (a,g)
Geuder, Paeschke & Frey Co., Wis (a,c,f,g)
Giant Grip Mfg. Co., Wis (a,c,e,f,g,h)
Gibson Electric Sales Corp., Pa (b)
Grammes, L.F. & Sons, Inc., Pa (a,b,g)
Grand Haven Stamped Products Co., Mich (a,b,g,j)
Grand Sheet Metal Products Co., Consumer Products Div., Ill (a,b,c,e,f,g,h,j)
Greene, G.G. Corp., Pa (a,b,e,f,g,j)
Greene Mfg. Co., Wis (a,g)
Grigoleit Co., Ill (a,g)
Grip Nut Co., Ind
Guarantee Specialty Mfg. Co., Ohio (a,b,c,g,j)
H.K. Metal Craft Mfg. Corp., NY (a,b,c,g,j)
H P L Mfg. Co., Ohio (a,b,g)
Haigh Mfg. Co., Mich (a,b,f)
Hardy Mfg. Corp., Ind (a,b,g)
Headly Mfg. Co., Ill (a,b,c,e,f,g,h,j)
Heintz Div., Kelsey-Hayes Co., Pa (g)
Heypian Mfg. Co., NJ (a,b,f,g)
Hoofer Mfg. Co., Ill (a,g)
Houston Blow Pipe & Sheet Metal Works, Tex (a,b,g)
Hunter Corp., Pa (a,b,c,f,g,h)
Hunter Spring Co., Div. of American Machine & Metals, Inc., Pa (a,b,f,g)
Ideal Can Co., Mass (a,b,c,g)
Illinois Zinc Co. Div., Hydrometals, Inc., Ill (j)
Indium Corp. of America, NY (d)
Indus Corp., Ind (g)
Industrial Precision Products, Ill (a,b,c,e,f,g,h,j)
Industrial Products Div., General Tire & Rubber Co., Ind
Ingram-Richardson, Inc., Ind (g)
Inshield Die & Stamping Co., Ohio (a,b,g)
Instrument Specialties Co., Inc., NJ (b)
Irwin-Sensenich Corp., Pa (a,g)
Jackson Auto Radiator, Ill (a,b,g)
Jarco Metal Products, NY (a,b,g,j)
Jervis Corp., Mich (a,b,g,h)
Joslyn Pacific Co., Calif (g)
Judd Industries, Inc., Ohio (a,b,f,g,j)
K-D Mfg. Co., Tex (g)
Kees, F.D. Mfg. Co., Neb (a,b,g)
Kelley Mfg. Co., Tex (a,b,g)
Kenmore Machine Products, Inc., NY (b)
Kickhaefer Mfg. Co., Wis (a,b,g)
King Laboratories, Inc., NY (a,b,c,f,g)
Kirchhof Patent Co., Inc., NY (a,b,c,f,g,j)
Kling Metal Spinning & Stamping Co., NY (a,b,c,d,e,f,g,j)
Koehler Mfg. Co., Mass (a,b,c,d,g)
Krueger & Hudepohl, Inc., Ohio (a,b,c,f,g)
Laminated Shim Co., Conn (a,b,g)
Lansing Stamping Co., Mich (g)
Larkin Specialty Mfg. Co., Calif (a,b,g)
Larson Tool & Stamping Co., Mass (a,b,c,e,f,g,h,j)
Laystrom Mfg. Co., Ill (a,b,c,f,g,j)
Leake Engineering Co., Mich (a,b,c,d,e,f,g,h,j)
Leake Stamping Div., Monarch Products Co., Mich (a,b,g)
Linden & Co., Inc., RI (a,b,g)
Littleford Bros. Inc., Ohio (a,b,c,f,g)

KEY

MATERIALS

a—Aluminum and its alloys	e—Magnesium and its alloys	j—Zinc and its alloys
b—Copper and its alloys	f—Nickel and its alloys	k—Thermoplastics
c—Iron and its alloys (except steel)	g—Steels	l—Thermosetting plastics
d—Lead and its alloys	h—Titanium and its alloys	m—Elastomers

BASIC FORMS

n—Anodes	r—Custom formed parts (incl. specialties)	v—Foil	aa—Powder
o—Bar	s—Fibers	w—Ingot	bb—Rod
p—Base resins, polymers or gums	t—Film	x—Laminating, casting resins	cc—Sheet
q—Billets	u—Foams (component materials or products)	y—Molding compounds	dd—Strip
		z—Plate	ee—Tubing
			ff—Wire

Lukens Steel Co., Pa (a,b,e,f,g,h)
Lundquist Tool & Mfg. Co., Inc., Mass (a,b,c,e,f,g,h)
Lynn, Gary Co., Ohio (a,b,g)
Machine Products Corp., Ohio (a,b,d,f, g)
Magline, Inc., Mich (e)
Magnesium Products of Milwaukee, Inc., Wis (a,e)
Magnetic Stamping Co., Pa (a,b,g)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (b)
Maloney, F.H. Co., Tex (g)
Manganese Steel Forge Co., Pa (g)
Manufacturers Service, Inc., Ohio (a, b,g)
Mayville Metal Products Co., Wis (a, b,g)
McDowell Mfg. Co., Pa (a,b,g)
McKinney Mfg. Co., Pa (a,b,e,f,g)
McLanahan & Stone Corp., Pa (c,g)
Melco Wire Products, Calif (a)
Melray Mfg. Co., Ill (a,b,c,d,e,f,g,h,j)
Metal Forming Corp., Div. of Vanadium-Alloys Steel Co., Pa (a,b,f,g)
Metal Parts & Stamping Co., Ohio (a,b,c,f,g,h,j)
Metallo Gasket Co., NJ (a,b,c,d,f,g,j)
Metallurgical Products Co., Pa (a,b,f, h,j)
Metals Engineering Corp., Tenn (a, b,d,e,g,j)
Micacraft Products, Inc., NJ (a)
Midwest Stamping & Mfg. Co., Ohio (a,b,f,g)
Milwaukee Stamping Co., Wis (a,b,g)
Mirro Aluminum Co., Wis (a)
Misner Corp., Neb (a,b,c,g)
Monarch Tool & Mfg. Co., Ky (a,b,c, g)
Morrison Steel Products, Inc., NY (g)
Morse, Fred W. Co., RI (a,b,c,g,j)
Morton Mfg. Co., Ill (a,g)
Mueller Machine Products, Inc., Wis (a,b,c,d,f,g)
National Gasket & Washer Mfg. Co., Inc., NY (a,b,c,d,e,f,g,h,j)
National Lead Co., NY (a,c,h)
National Lock Co., Ill (a,b,c,d,g)
National Metal Products Co., Pa (a, c,g)
National Supply Div., Armco Steel Corp.,Pa (g)
Nichols, L.O. & Son Mfg. Co., Mo (a, b,c,g)
Nigg Engineering Corp., Calif (a,b,c,g)
Noera Mfg. Co., Conn (a,b,g)
Noland Tank & Galvanizing Co., Tenn
Norcross, C.S. & Sons Co., Ill (g)
Nylok Corp., NJ (a,b,c,e,g)
Ohio Nut & Washer Co., Ohio (a,g)
Olean Electro Plating Co., NY (a,b,g)
Ormond Mfg., Co., Inc., NJ (a,b,f,j)
Pabst Engineering Equipment Co., Inc., NJ (a,b,c,e,f,g)
Paragon Spring Co., Ill (a,b,c,f,g)
Parish Pressed Steel Div., Dana Corp., Pa (a,g)
Parker, Charles Co., Conn (a,f)
Parker Metal Goods Co., Mass (a,b,g)
Peck Spring Co., Conn (a,b,c,f,g,h)
Peerless Products Industries, Ill (a, b,g)
Pemco Wheel Co., Mich (g)
Penn Fibre & Specialty Co., Inc., Pa (a,b,c,d,e,f,g,j)
Penrod, Floyd & Sons Tool & Engineering Corp., Ind (a,b,g)
Perrin, Edward C. Co., NJ (a,b,g)
Peterson Products Corp., Ill (a,b,f,g)
Philadelphia Enameling Works Inc., Pa (a,b,g)
Phoenix Steel Corp., NY (g)
Pioneer Stamped Products Co., NY (a, b,c,d,e,f,g,h)
Pittsburgh Forgings Co., Mich (g)
Plume & Atwood Mfg. Co., Conn (a,b,f,g)
Porter, H.K., Inc., Forge & Fittings Div., Ohio (a,g)
Powell Pressed Steel Co., Ohio (a,g)
Premier Metal Works, Inc., Ill (a,b, f,g)
Pressed Steel Co., Pa (a,b,d,f,g,j)
Presswork, Inc., Mich (a,b,c,d,f,g,j)
Prestole Corp., Ohio (a,g)

Queen Products Co., Inc., Ky (a,b,g)
Reed & Prince Mfg. Co., Mass (a,b, f,g)
Regal Ware, Inc., Wis (a,b,g)
Reichert Float & Mfg. Co., Ohio
(a,b,c,d,f,j)—Ad p 418
Reliable Spring & Wire Forms Co., Ohio (a,b,f,g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (a, b,c,f,g,j)
Reynolds Metals Co., Va (a)
Rochester Novelty Works, Inc., NY (a,b,g)
Rockwell Engineering Co., Ill (a,b,c,g)
Rockwell - Standard Corp., Stamping Div., NY
(a,b,d,f,g)—Ad p 412
Rohr Aircraft Corp., Calif (a,e,g,h)
Rolock, Inc., Conn (f)
Roth Steel Products Co., Ohio (g)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
S.T.D. Div., Pierce Industries, Inc. of Ohio, Ohio (a,g)
St. Marys Carbon Co., Pa (b)
Sargent & Greenleaf, Inc., NY (a,b,g)
Scovill Mfg. Co., Mill Products Div., Conn (a,b,c,f,g)
Security Cos., Mich (a)
Security Sash & Screen Co., Mich (a)
Servwell Products Co., Ohio (b,g)
Shakeproof Div., Illinois Tool Works, Ill (b,g)
Shank Metal Products Co., NY (a,g)
Shelby Mfg. Co., Ohio (g)
Sheller Mfg. Corp., Mich (g)
Sierra Electric Corp., Calif (b,g)
Sillcocks Miller Co., NJ (a,b,f,g)
Simonsen Metal Products Co., Ill (a, g)
Sinclair Co., Mass (b,g)
Sioux City Foundry & Boiler Co., Iowa (g)
Smithers Tool & Machine Products, Inc., NY (g)
Smith-Victor Corp., Ind (a,g)
Smoot-Holman Co., Calif (g)
Sommer Metalcraft Corp., Ind (a,g)
South River Metal Products Co., Inc., NJ (a,e,g)
Southern Car & Mfg. Co., Inc., Ala (a,b,g)
Southwestern Porcelain Steel Corp., Okla (g)
Spincraft, Inc., Wis (a,b,c,d,e,f,g,h,j)
Stainless Metals, Inc., NY (c,f,h)
Stamford Metal Specialty Co., Inc., NY (a,f,g)
Standard Forge & Axle Co., Inc., Ala (g)
Standard Nut & Bolt Co., RI (a,b,f,g)
Standard Steel Sections, Inc., NY (a, b,c,g)
Stanley Industrial Sales, Stanley Works, Conn (g)
Star Heel Plate Co., Inc., NJ (a,b,g)
Star Stamping Co., Mich (a,b,g)
Staver Co., Inc., NY (a,b,c,d,e,f,g,h,j)
Steel Heddle Mfg. Co., Pa (a,b,c,e,f,g, h,j)
Steel Industries, Inc., Ind (a,b,g)
Steinen, Wm. Mfg. Co., NJ (a,b,c,g)
Stenman, Brer F., Mass (a,g)
Stimpson, Edwin B. Co., Inc., NY (a,b,f,g,j)
Stirrup Metal Products Corp., NJ (a, b,c,g)
Superior Mfg. Co., Pa (g,j)
Superior Spinning & Stamping Co., Ohio (a,b,f,g)
Sylvania Electric Products Inc., Parts Div., Pa (a,b,c,f,g)
Textile Shield Co., Inc., Mass (a,b,g)
Thompson Products, Inc., Ohio (g)
Thompson-Bremer & Co., Ill (a,b,c,f, g,h)
Titchener, E.H. & Co., NY (a,b,f,g)
Toledo Stamping & Mfg. Co., Ohio (a,b,g,h)
Transue & Williams Steel Forging Corp., Ohio (f,g)
Triangle Stamping Co., Ohio (a,b,c,d,f, g,j)

Turner & Seymour Mfg. Co., Conn (a, b,g)
United Metal Products Corp., Mich (a,b,c,g)
United Screw & Bolt Corp., Ill (a, b,g)
United Shoe Machinery Corp., Mass (a,b,f,g,j)
U.S. Gasket & Shim Co., Ohio (a, b,c,d,e,f,g,h,j)
United-Carr Fastener Corp., Mass (a, b,g)
Unity Machine & Tool Corp., Pa (a, b,g)
Vacuum Technology, Inc., Calif (h)
Van Valkenburg, L.A. Co., Mass (a, b,c,d,f,g)
Variety Stamping Corp., Ohio (a,b,c,g)
Volkert Stampings, Inc., NY (b,f,g)
Vulcan Metal Products, Inc., Ala (a)
WLS Stamping Co., Ohio (a,b,c,d,e, f,g,h,j)
Wabash Metal Products Co., Inc., Ind (a,b,g)
Wagner, E.P. Mfg. Co., Wis (a,b,c,g, j)
Wagner Specialty Co., Wis (a,b,c,g, j)
Wall, P. Mfg. Co., Pa (a,b,g)
Wall Tube & Metal Products Co., Tenn (g)
Ward, H.H. Co., Pa (a,b,c,f,g,j)
Warren Plastics & Engineering, Inc., Mich (a,b,c,d,e,f,g,h,j)
Waterbury Buckle Co., Conn (a,g,j)
Waterbury Cos., Inc., Conn (a,b,g)
Waterbury Pressed Metal Co., Conn (a,b,f,g)
Waterman Industrial, Inc., Calif (a, b,g)
Wayne Foundry & Stamping Co., Mich (a,b,e,g,h)
Weatherhead Co., Ind (a,b,g,h)
Weber-Knapp Co., NY (a,g)
Welding Apparatus Co., Ill (a,f,g)
Wesbar Stamping Corp., Wis (a,g)
Wesco Spring Co., Ill (g)
Western Tool & Die Works, Ore (a,b, g)
Wilder Mfg. Co., Inc., Calif (a,c,g)
Williams, F.B. Co., Ill (g)
Williams, H.E. Products Co., Mo (a, b,c,g,j)
Wilson-Hurd Mfg. Co., Inc., Wis (a)
Wirth, Carl & Son, Inc., NY (a,b,c,g)
Wisconsin Gasket & Mfg. Co., Wis (a,b,g)
Wood, John Co., Minn (g)
Woolf Aircraft Products, Inc., Mich (a,b,g)
Worcester Pressed Steel Co., Mass (a, b,c,e,f,g,h,j)
Worcester Stamped Metal Co., Mass (a,b,e,f,g,h,j)
Worth Co., Wis (a,b,c,g)
Wrought Washer Mfg. Co., Wis (a,b, d,e,f,g,h,j)
Wuest Bros., Inc., Ky (a,b,c,f,g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)
Youngstown Mfg., Inc., Ohio (a,g)
Youngstown Sheet and Tube Co., Ohio (g)

Steatite

(see Ceramics)

Steel, Carbon

Acme-Newport Steel Co., Ky (w,z,ce)
Advance Screw Products Co., Inc., Wis (o)
Advance Stamping Co., Mich (dd)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (ee)
Alan Wood Steel Co., Pa (q,w,z,cc,dd)
Albert Pipe Supply Co., NY (ee)
Albert Wright Screw Machine Products, Calif (bb)
Alco Products, Inc., NY (q,aa)
Allegheny Ludlum Steel Corp., Pa (dd)
Alloy Metal Powders, Inc., Iowa (aa)
Almco Steel Products Corp., Ind (o, z,bb,cc,dd)
Amalgamated Steel Corp., Ohio (o,bb)
American Cast Iron Pipe Co., Ala (ee)
American Metal Products, Inc., Ohio (z,cc)
American Silver Co., NY (v,dd)
American Steel and Wire Div., U. S. Steel Corp., Ohio
(o)—Ad pp 90-91
Ames, W. & Co., NJ (o)
Anchor Drawn Steel Co., Div. of Vanadium-Alloys Steel Co., Pa (bb,ff)
Appalachian Steel Corp., NJ (cc,dd,ff)
Aristoloy Steel Div., Copperweld Steel Co., Ohio (o,q,w)
Armco Steel Corp., Ohio (o,z,bb,cc, dd,ff)
Armco Steel Corp., Sheffield Div., Mo (o,q,w,z,bb,cc,dd,ff)
Athenia Steel Div., National Standard Co., NJ (dd)
Atlantic Steel Co., Ga (o,q,w,z,bb,cc, dd,ee,ff)
Austenal Co., Div. of Howe Sound Co., NY (w)
Babcock & Wilcox Co., Tubular Products Div., Pa (ee)
Baxter Foundry & Machine Works, Inc., Id (o,z,bb,cc,dd)
Bethlehem Steel Co., Pa (o,q,z,bb, cc,dd,ee,ff)
Biddle Screw Products Co., Ind (o,bb, ee)
Blair Strip Steel Co., Pa (dd)
Bliss & Laughlin, Inc., Ill (o)
Brainard Steel Div., Sharon Steel Corp., Ohio (ee)
Burkhardt Steel Co., Colo (o,z,cc,dd, ee)
Byers, A.M. Co., Pa (o,q,w,z,cc,dd)
Cannon-Muskegon Corp., Mich (w)
Carpenter Steel Co., Webb Wire Div., NJ (ff)
Caspers Tin Plate Co., Ill (cc,dd)
Castle, A.M. & Co., Ill (o,z,bb,cc, dd,ee,ff)
Central Fabricators, Inc., Ohio (z, bb,cc,ee)
Central Steel & Wire Co., Ill (o,z, bb,cc,dd,ee,ff)
Chicago Steel Service Co., Ill (o,z, bb,cc,dd)
Clark Perforating Co., Mich (cc,dd)
Clayton Mark & Co., Ill (ee)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (o,q,w,z,bb,cc,ff)
Colorado Fuel and Iron Corp., Colo
Columbia-Geneva Steel Div., U. S. Steel Corp., Calif (o,q,z,cc,dd,ee)
Connors Steel Div., H.K. Porter Co., Inc., Ala (o,q,w,dd)
Continental Steel Corp., Ind (o,q,bb,ff)
Crucible Steel Co. of America, Pa (o,q,w,z,bb,cc,dd,ff)
Cumberland Steel Co., Md (o)
Designers Metal Corp., Ill (cc)
Detroit Steel Corp., Portsmouth Div., Mich (q,w,bb,cc)
Dixon Sintaloy, Inc., Conn (o)
Dudek & Bock Spring Mfg. Co., Ill (dd,ff)
Eaton Mfg. Co., Reliance Div., Ohio (o,ff)
Edgcomb Steel & Aluminum Corp., NJ (o,z,cc,dd)
Elliott Bros. Steel Co., Pa (cc,dd)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (z,cc)
Enterprise Wheel & Car Corp., Va (o, z,cc)
Eynon-Dakin Co., Mich (ee)
Finkl, A. & Sons Co., Ill (w)
Follansbee Steel Corp., W.Va (cc,dd)
Forg, Peter Mfg. Co., Mass (cc)
Fort Howard Steel & Wire Co., Wis (o)
Franklin Steel Div., Borg-Warner Corp., Pa (o)
Frasse, Peter A. & Co., Inc., NY (o,bb,cc,dd,ee,ff)
Fromson Orban Co., Inc., NY (ee)
Gary Steel Products Corp., Va (o,z,cc)

General Chain & Mfg. Corp., Ohio (ff)
General Motors Corp., Rochester Products Div., NY (ee)
Granite City Steel Co., Ill (w,z,cc)
Great Lakes Steel Corp., Div. of National Steel Corp., Mich (o,z,cc,dd)
Green River Steel Corp., Ky (o,q,w)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (o,bb,ee,ff)
Haydon Corp., NY (ee)
Houston Blow Pipe & Sheet Metal Works, Tex (o,z,cc)
Inland Steel Co., Ill (o,z,cc,dd)
Inshield Die & Stamping Co., Ohio (cc)
Isaacson Iron Works, Wash (q,w)
Jackson Steel Products, Inc., NY (ee)
Jones & Laughlin Steel Corp., Pa (o,q,z,bb,cc,dd,ee,ff)
K-D Mfg. Co., Tex (o)
Kaiser Steel Corp., Calif (o,q,w,z,bb,cc,dd,ee)
Keystone Drawn Steel Co., Pa (o)
Keystone Steel & Wire Co., Ill (w,bb)
Kinkead Industries, Inc., Ill (o,z,bb,cc,dd)
Korhumel Steel and Aluminum Co., Ill (o,z,bb,cc,dd,ff)
Kwikset Powdered Metal Products, Calif (aa)
Laclede Steel Co., Mo (o,q,w,bb,dd,ee,ff)
Larson, Charles E. & Sons, Inc., Ill (o)
La Salle Steel Co., Ill (o)
Le Tourneau, R.G., Inc., Tex (z)
Levinson Steel Co., Pa (o,z,bb,cc,dd)
Lock Joint Tube Co., Inc., Ind (ee)
Lockhart Iron & Steel Co., Pa (o,q,z,bb,cc,dd,ee)
Lockport Mfg. Co., Ill (z)
Lukens Steel Co., Pa (w,z)
Lundquist Tool & Mfg. Co., Inc., Mass (bb,cc,dd,ee,ff)
Mahon, R.C. Co., Mich (o,z,cc,dd)
Makepeace, D.E. Div., Engelhard Industries Inc., Mass (o,dd,ee)
McCarter Iron Works, Inc., Pa (o,z,bb,cc)
McGregor-Michigan Corp., Mich (z)
McInnes Steel Co., Pa (o)
McLouth Steel Corp., Mich (cc,dd)
Metal Forming Corp., Div. of Vanadium-Alloys Steel Co., Ind (ee)
Metal Goods Corp., Mo (o,z,bb,cc,dd,ee)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Michigan Seamless Tube Co., Mich (ee)
Midvale-Heppenstall Co., Pa (w)
Modern Plating Corp., Ill (z)
Moltrup Steel Products Co., Pa (o)
Morrisville Foundry Co., Inc., Vt (z,bb,cc,dd)
Murray, A.B. Co., Inc., NJ (ee)
Narragansett Boiler Works, Inc., RI (o,z,bb,cc,ee)
National Galvanizing Co., Pa (z,bb,cc,ee)
National Lock Washer Co., NJ (ff)

National Supply Div., Armco Steel Corp., Pa (o,q,w)
National Tube Div., U.S. Steel Corp., Pa (ee)
National U.S. Radiator Corp., Plastic Metals Div., Pa (aa)
National-Standard Co., Mich (dd,ff)
Nesor Alloy Products Co., NJ (ff)
New York Iron Roofing & Corrugating Co., Inc., NJ (cc)
Newman-Crosby Steel Co., RI (dd)
Nikoh Tube Co., Ill (bb,cc,dd,ee)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Northwestern Steel & Wire Co., Ill (o,q,w,z,bb,ff)
Norwalk Powdered Metals, Inc., Conn (aa)
Ohio Seamless Tube Div., Copperweld Steel Co., Ohio (ee)
Ormond Mfg. Co., Inc., NJ (cc,dd,ff)
Pacific States Steel Corp., Calif (o,q,w)
Pacific Tube Co., Calif (o,ee)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (ff)
Peninsular Steel Co., Mich (o,z)
Phoenix Mfg. Co., Ill (o)
Phoenix Steel Corp., NY (q,w,z,ee)
Pittsburgh Forgings Co., Mich (o,q)
Pittsburgh Steel Co., Pa (q,w,bb,cc,dd,ee,ff)
Precision Tube Co., Inc., Pa (ee)
Purdy, A.R. Co., Inc., NJ (o,z,bb,cc,dd,ff)
Rathbone Corp., Mass (o,bb)
Reactive Metals, Inc., Ohio (cc)
Republic Steel Corp., Ohio (o,q,w,z,bb,cc,dd,ee,ff)
Reynolds Aluminum Supply Co., Ga (cc)
Rigidized Metals Corp., NY (cc,dd)
Riverside-Alloy Metal Div., H. K. Porter Co., Inc., NJ (ff)
Rodney Metals, Inc., Mass (v,dd)
Roebling's, John A. Sons Div., Colorado Fuel & Iron Corp., NJ (bb,dd,ff)
Rome Mfg. Div., Revere Copper & Brass Inc., NY (ee)
Rome Strip Steel Co., Inc., NY (o,z,dd,ff)
Ross-Meehan Foundries, Tenn (o)
Ryerson, Joseph T. & Son, Inc., Ill (o,q,z,bb,cc,dd,ee,ff)
St. Louis Steel Casting, Inc., Mo (o)
Sandusky Foundry & Machine Co., Ohio (ee)
Sandvik Steel, Inc., NJ (dd)
Saran Lined Pipe Co., Div. of Michigan Pipe Co., Mich (ee)
Sawhill Tubular Products, Inc., Pa (ee)
Scudder, E.J. Foundry & Machine Co., NJ (bb,ee)
Service Steel Div., Van Pelt Corp., Mich (ee)
Sharon Steel Corp., Pa (q,w,z,cc,dd)
Shaw-Kendall Engineering Co., Ohio (aa)
Sherwatt Equipment & Mfg. Co., Inc., NY (ff)

Simonds Saw & Steel Co., Mass (o,cc)
Simoniz Products Div., Simoniz Co., Ill (cc)
Smith-Moon Steel Co., Inc., Kan (o,z,cc)
Solar Steel Corp., Ohio (o,bb,cc,dd,ee)
Sonken-Galamba Corp., Kan (z,bb,cc,ee)
Southern Fabricating Co., Inc., Ala (ee)
Stainless and Strip Div., Jones & Laughlin Steel Corp., Ohio (dd)
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (q,w)
Star Heel Plate Co., Inc., NJ (o,z,bb,cc,dd,ee,ff)
Sun Steel Co., Ill (o,q,z,bb,cc,dd)
Superior Drawn Steel Co., Pa (o,bb,ff)
Superior Steel Div., Copperweld Steel Co., Pa (dd)
Superior Tube Co., Pa
(ee)—Ad pp 424-425
Sylvania Electric Products, Inc., Parts Div., Pa (ff)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (o,q,z,cc,dd)
Thomas Strip Div., Pittsburgh Steel Co., Pa (dd)
Thompson Industries, Inc., NY (bb)
Thompson Wire Co., Mass (dd)
Timken Roller Bearing Co., Steel & Tube Div., Ohio (ee)
Topeka Foundry & Iron Works Co., Inc., Kan (o,z,bb,cc,dd)
Trojan Steel Co., W.Va (o,z,bb,cc,dd)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Uddeholm Co. of America, Inc., NY (bb,dd,ee)
Udylite Corp., Mich (n)
Ullmann, Inc., Wis (o,ee)
Union Iron Works, Wash (o,z,cc,dd,ee)
Union Steel Corp., NJ (dd)
United Screw & Bolt Corp., Ill (bb,cc,dd,ff)
U.S. Challenge & Challenge Co., Ill (bb)
U.S. Gasket & Shim Co., Ohio (cc,dd)
U.S. Steel Corp., Pa (o,q,z,cc,dd)
U.S. Steel Supply Div., U.S. Steel Corp., Ill (o,z,cc,dd,ee)
Vanadium-Alloys Steel Co., Pa (o,q,w,z,aa,bb,cc,dd,ee,ff)
Vulcan Rail & Construction Co., NY (o,dd,ee)
Vulcan-Kidd Steel Div., H.K. Porter Co., Inc., Pa (o,q,w,bb,ff)
Wal-Mar Corp., Ill (ee)
Washburn Wire Co., Phillipsdale Div., RI (q,bb,dd)
Weirton Steel Co., Div. of National Steel Corp., W.Va (cc)
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (n)
Western Iron & Foundry Co., Inc., Kan (o,z,bb,cc,dd)
Wheatland Tube Co., Pa (ee)
Wickwire Bros., Inc., NY (bb,ff)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (q,ff)
Wilson Steel & Wire Co., Ill (ff)
Wisconsin Steel Co., Div. of International Harvester Co., Ill (o,q)

Wycoff Steel Co., Pa (o,z)
Youngstown Sheet and Tube Co., Ohio (o,z,bb,cc,dd,ee,ff)

Steel, Carbon—Castings

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Adirondack Steel Casting Co., NY
Advance Foundry Co., Ohio
Allied Steel Castings Co., Ill
All-Metals Precision Casting Corp., NY
Alloy Cast Steel Co., Ohio
Alloy Precision Castings Co., Ohio
Alloy Steel & Metals Co., Calif
American Cast Iron Pipe Co., Ala
American Steel Foundries, Ill
Arneson Foundry Co., Wis
Arwood Corp., NY
Atlantic Foundry Co., Ohio
Atlantic Steel Castings Co., Pa
Austenal Co., Div. of Howe Sound Co., NY
Auto Specialties Mfg. Co., Mich
Baldwin-Lima-Hamilton Corp., Pa
Bay City Electric Steel Casting Co., Mich.
Beaver Valley Alloy Foundry Co., Pa
Bethlehem Steel Co., Pa
Birdsboro Steel Foundry & Machine Co., Pa
Blaw-Knox Co., Pa
Bone Engineering Corp., Calif
Calumet Steel Castings Corp., Ind
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Commercial Steel Casting Co., Ohio
Crucible Steel Casting Co., Pa
Dayton Steel Foundry Co., Ohio
Dodge Steel Co., Pa
Eastern Malleable Iron Co., Del
Electric Steel Castings Co., Ind
Electrocast Steel Foundry Co., Ill
Empire Foundry Co., Inc., Calif
Empire Steel Castings, Inc., Pa
Engineered Castings Div., American Brake Shoe Co., NY
Esco Corp., Ore
Falk Corp., Wis
Farrel-Birmingham Co., Inc., Conn
Federal Steel Products Corp., Tex
Fort Pitt Steel Casting Div., Pittsburgh Steel Foundry Corp., Pa
General Electric Co., Foundry Dept., NY
General Steel Castings Corp., Ill
Glover Machine Works, Ga
Goslin Birmingham Mfg. Co., Inc., Ala
Grede Foundries, Inc., Wis
Gunite Foundries Corp., Ill
Hartford Electric Steel Corp., Conn
Hica, Inc., La
Hitchiner Mfg. Co., Inc., NH
Howard Foundry Co., Ill
Hughes Tool Co., Tex
Humphrey Castings, Inc., Calif
Illinois Precise Casting Co., Ill
Kay-Brunner Steel Products, Inc., Calif
Kwikset Powdered Metal Products, Calif
LFM Mfg. Co., Inc., Sub. of Rockwell Mfg. Co., Kan
Lebanon Steel Foundry, Pa
Lectromelt Casting Div., Akron Standard Mold Co., Ohio
Liberty Foundry Co., Mo
Los Angeles Steel Casting Co., Calif
Mackintosh-Hemphill Div., E.W. Bliss Co., Pa
Manco Products, Inc., Mich
Massillon Steel Casting Co., Ohio
Midwest Precision Castings Co., Ohio
Minneapolis Electric Steel Castings Co., Minn
Misco Precision Casting Co., Mich
Missouri Steel Castings Co., Mo
Monroe Steel Castings Co., Mich
National Malleable & Steel Castings Co., Ohio
National Precision Casting Corp., Div. of Beryllium Corp., Pa
National Supply Div., Armco Steel Corp., Pa

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Ohio Steel Foundry Co., Ohio
Oklahoma Steel Castings Div., American Steel & Pump Corp., Okla
Olympic Steel Works, Wash
Omaha Steel Works, Neb
Pelton Steel Casting Co., Wis
Penn Steel Castings Co., Pa
Picco, Inc., Calif
Pittsburgh Steel Foundry Corp., Pa
Pratt & Letchworth Div., Dayton Malleable Iron Co., Inc., NY
Precision Founders, Inc., Calif
Quaker Alloy Casting Co., Pa
Quality Electric Steel Castings, Inc., Tex
Quincy Steel Casting Co., Mass
Racine Steel Castings Co., Wis
Reliance Steel Castings Co., Pa
Rockwell Engineering Co., Ill
Ross-Meehan Foundries, Tenn
St. Louis Steel Casting, Inc., Mo
Sandusky Foundry & Machine Co., Ohio
Sawbrook Steel Castings Co., Ohio
Scullin Steel Co., Mo
Sivyer Steel Casting Co., Wis
Sorbo-Mat Process Engineers, Mo
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa
Star Heel Plate Co., Inc., NJ
Strong Steel Foundry Co., NY
Superior Foundry, Inc., Ohio
Superior Steel & Malleable Castings Co., Mich
Swedish Crucible Steel Co., Mich
Symington Div., Symington Wayne Corp., NY
Texas Foundries, Inc., Tex
Texas Steel Co., Tex
Thys Co., Calif
Union Iron Works, Wash
Union Spring & Mfg. Co., Pa
Unitcast Corp., Ohio
U.S. Pipe & Foundry Co., Ala
Utility Steel Foundry, Calif
Valley Steel Casting Co., Mich
Vascoloy-Ramet Corp., Ill
Viking Pump Co., Iowa
Vulcan Iron Works, Pa
Washington Iron Works, Wash
West Steel Casting Co., Ohio
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
Westlectric Castings, Inc., Calif
Westmoreland Malleable Iron Co., NY
Worthington Corp., NJ

Steel, Heat and Corrosion Resistant

Acme Tube, Inc., NJ (ee)
Advance Stamping Co., Mich (dd)
Albert Pipe Supply Co., Inc., NY (ee)
Albraco Metals Co., NY (o,q,bb,ee,ff)
Alco Products, Inc., NY (q)
Allegheny Ludlum Steel Corp., Pa (o,q,w,z,bb,cc,dd,ee,ff)
Alloy Metal Powders, Inc., NY (aa)
Alloy Metal Products, Inc., Iowa (o,q,w)
Alofs Mfg. Co., Mich (dd)
American Cast Iron Pipe Co., Ala (ee)
American Silver Co., NY (v,dd,ee,ff)
American Steel & Wire Div., U.S. Steel Corp., Ohio (ff)—Ad pp 90-91
Anchor Drawn Steel Co., Div. of Vanadium-Alloys Steel Co., Pa (bb, ff)
Arcos Corp., Pa (ff)
Aristoloy Steel Div., Copperweld Steel Co., Ohio (o,q)
Armco Steel Corp., Ohio (o,q,v,z,bb, cc,dd,ff)
Athenia Steel Div., National-Standard Co., NJ (dd)
Austenal Co., Div. of Howe Sound Co., NY (w)
Babcock & Wilcox Co., Tubular Products Div., Pa (ee)
Bethlehem Steel Co., Pa (o,q,z,bb,cc, dd,ee,ff)
Biddle Screw Products Co., Ind (o, bb,ee)
Bishop, J. & Co., Platinum Works, Pa (ee)
Brinkerhoff Brass & Bronze Works, Inc., NY (z,bb,cc)
Brush Beryllium Co., Ohio (v,dd)
Byers, A.M. Co., Pa (o,q,w,z,cc,dd)
Cannon-Muskegon Corp., Mich (w)
Carlson, G.O., Inc., Pa (o,z,cc)
Carpenter Steel Co., Pa (o,q,w,bb,dd, ee,ff)
Carpenter Steel Co., Alloy Tube Div., NJ (ff)
Carpenter Steel Co., Webb Wire Div., NJ (ff)
Castle, A.M. & Co., Ill (o,q,z,cc,dd,ff)
Central Fabricators, Inc., Ohio (z,bb, cc,ee)
Central Steel & Wire Co., Ill (o,z,bb, cc,dd,ee,ff)
Chromalloy Corp., NY (cc)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (o,q,w,z,bb,cc,ff)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (o,q,w,z,cc,dd, ee,ff)
Crucible Steel Co. of America, Pa (o,q,w,z,bb,cc,dd,ee,ff)—Ad p 89
Curtiss-Wright Corp., Metals Processing Div., NY (ee)
Damascus Tube Co., Pa (ee)
Dixon Sintaloy, Inc., Conn (o)
Driver, Wilbur B. Co., NJ (v,bb,dd, ff)
Dudek & Bock Spring Mfg Co., Ill. (dd,ff)
Eastern Stainless Steel Corp., Md (z, cc,dd)
Eaton Mfg. Co., Reliance Div., Ohio (o,ff)
Edgcomb Steel & Aluminum Corp., NJ (o,z,cc,dd)
Erskine Precision Wire Corp., Pa (ff)
Esco Corp., Ore (o,q,w,z,bb,cc,dd,ee,ff)
Eynon-Dakin Co., Mich (ee)
Firth Sterling, Inc., Pa (o,q,w,bb,ff)
Frasse, Peter A. & Co., Inc., NY (o, bb,cc,dd,ee,ff)
Fromson Orban Co., Inc., NY (ee)
Gary Steel Products Corp., Va (o,z,cc)
General Electric Co., Metallurgical Products Dept., Mich (q,aa,bb,cc,dd)
Green River Steel Corp., Ky (o,q,w)
Hamilton Watch Co., Precision Metals Div., Pa (v,cc,dd,ff)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (o, z,bb,dd,ee,ff)
Haydon Corp., NY (ee)
Hexcel Products, Inc., Calif (v)
Hoeganaes Sponge Iron Corp., NJ (aa)—Ad p 428
Industrial Stainless Steels, Inc., Mass (o,q,z,bb,cc,dd,ee,ff)
Jessop Steel Co., Pa (o,q,z,cc,dd,ee)
Jones & Laughlin Steel Corp., Pa (o, q,cc,dd)
Joslyn Stainless Steels, Ill (o,q,w,bb, ff)
Kaiser Steel Corp., Calif (o,q,w,z,bb, cc,dd)
Kelsey-Hayes Co., Mich (o,q,z,cc)
Kinkead Industries, Inc., Ill (cc,dd)
Kirk & Blum Mfg Co., Ohio (z,cc)
Kolcast Industries Div., Thompson Products, Inc., Ohio (q,w)
Krueger Fabricating Co., Inc., Wis (cc)
Kwikset Powdered Metal Products, Calif (aa)
Larson, Charles E. & Sons Inc., Ill (o)
Latrobe Steel Co., Pa (o,q,w)
Lockport Mfg. Co., Ill (z)
Lukens Steel Co., Pa (w,z)
Lundquist Tool & Mfg. Co., Inc., Mass (bb,cc,dd,ee,ff)
Makepeace, D.E. Div., Engelhard Industries Inc., Mass (o,dd,ee)
McCarter Iron Works, Inc., Pa (o,z, bb,cc)
McInnes Steel Co., Pa (o)
Meier Brass & Aluminum Co., Mich (z,bb,cc)
Metal Goods Corp., Mo (o,z,bb,cc,dd, ee,ff)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Michigan Seamless Tube Co., Mich (ee)
Midvale-Heppenstall Co., Pa (w)
Mott Metallurgical Corp., Ill (porous)
Murray, A.B. Co., Inc., NJ (ee)
National Electric Div., H.K. Porter Co., Inc., Pa (ee)
National Supply Div., Armco Steel Corp., Pa (o,q,w)
National Tube Div., U.S. Steel Corp., Pa (ee)
National-Standard Co., Mich (dd,ff)
New Jersey Metals Co., NJ (w)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (ff)
Pencoyd Steel & Forge Corp., Pa (o, q,w)
Phoenix Steel Corp., NY (z)
Precision Tube Co., Inc., Pa (ee)
Purdy, A.R. Co., Inc., NJ (o,z,bb,cc, dd,ff)
Rathbone Corp., Mass (o,bb)
Republic Steel Corp., Ohio (o,q,w,z,bb,cc,dd,ee,ff)—Ad pp 86-87
Republic Supply Co. of California (o, q,z,bb,cc,ee,ff)
Reynolds Aluminum Supply Co., Ga (o, z,bb,cc,dd,ee)
Riverside-Alloy Metal Div., H.K. Porter Co., Inc., NJ (bb,dd,ff)—Ad p 150
Rodney Metals, Inc., Mass (v,dd)
Rolled Alloys, Inc., Mich (o,q,z,bb, cc,dd,ee,ff)
Rome Mfg. Div., Revere Copper & Brass Inc., NY (ee)
Ross-Meehan Foundries, Tenn (o)
Ryerson, Joseph T. & Son, Inc., Ill (o,q,z,bb,cc,dd,ee,ff)
St. Louis Steel Casting, Inc., Mo (n)
Sandusky Foundry & Machine Co., Ohio (ee)
Sandvik Steel, Inc., NJ (dd,ee,ff)
Service Steel Div., Van Pelt Corp., Mich (ee)
Seymour Mfg. Co., Conn (dd)
Sharon Steel Corp., Pa (q,w,z,cc,dd)
Sheldon, M. L. & Co., Inc., NY (ee)
Sherwatt Equipment & Mfg. Co., Inc., NY (ff)
Simonds Saw & Steel Co., Mass (o, cc)
Smith-Moon Steel Co., Kan (o,z,cc,dd)
Solar Steel Corp., Ohio (o,z)
Somers Brass Co., Inc., Conn (v,dd)—Ad p 158
Stainless and Strip Div., Jones & Laughlin Steel Corp., Mich (o,q,w, bb,cc,dd,ff)
Stainless and Strip Div., Jones & Laughlin Steel Corp., Ohio (dd)
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (q,w)
Star Heel Plate Co., Inc., NJ (z,ff)
Sun Steel Co., Ill (cc,dd)
Superior Drawn Steel Co., Pa (o, bb,ff)
Superior Mfg. Co., Pa (dd,ff)
Superior Steel Corp., Pa (dd)
Superior Steel Div., Copperweld Steel Co., Pa (dd)
Superior Tube Co., Pa (ee)—Ad pp 424-425
Sylvania Electric Products, Inc., Parts Div., Pa (ff)
Techalloy Co., Inc., Pa (v,bb,dd,ff)
Temescal Metallurgical Corp., Calif (o,q,w,z)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (o,q,w,z,cc,dd,ff)
Timken Roller Bearing Co., Steel & Tube Div., Ohio (o,q,ee)
Trent Tube Co., Pa (ee)
Tube Distributors Co., Inc., NY (ee)
Tube Methods, Inc., Pa (ee)
Tube Reducing Corp., NJ (ee)
Uddeholm Co. of America, Inc., NY (bb,dd)
Ulbrich Stainless Steels Corp., Conn (dd)
Ullmann, Inc., Wis (o,ee)
Union Steel Corp., NJ (dd,ee)
United Screw & Bolt Corp., Ill (bb, cc,dd,ff)
U.S. Challenge & Challenge Co., Ill (bb)
U.S. Gasket & Shim Co., Ohio (cc,dd)
U. S. Steel Corp., Pa (o,q,w,z,cc,dd, ee)
U.S. Steel Supply Div., U.S. Steel Corp., Ill (o,z,cc,ee)
Universal-Cyclops Steel Corp., Pa (o, q,z,bb,cc,dd,ff)
Uniworld Research Corp. of America, Ohio (o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Vanadium-Alloys Steel Co., Pa (o,q,w, z,aa,bb,cc,ee,ff)
Vulcan Rail & Construction Co., NY (o,dd,ee)
Vulcan-Kidd Steel Div., H.K. Porter Co., Inc., Pa (o,q,z,bb,ff)
Waimet Alloys Co., Mich (w)
Wall Colmonoy Corp., Mich (aa, bb,ff)
Wall Tube & Metal Products Co., Tenn (ee)
Wallingford Steel Co. Conn (v,dd)
Washington Steel Corp., Pa (cc,dd)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,w,z,bb,cc,dd,ee)
Whitehead Metal Products Co., Inc., NY (z,bb,cc,dd)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (q,ff)
Wisconsin Centrifugal Foundry Inc., Wis (ee)
Worcester Wire Works Div., National-Standard Co, Mass (ff)

Steel, Heat and Corrosion Resistant—Castings

Adirondack Steel Casting Co., NY
Aelco Foundries, Inc., Wis
Allegheny Ludlum Steel Corp., Pa
All-Metals Precision Casting Corp., NY
Alloy Engineering & Casting Co., Ill
Alloy Precision Castings Co., Ohio
Alloy Steel Casting Co., Pa
American Brake Shoe Co., NY
American Cast Iron Pipe Co., Ala
American Steel Foundries, Ill
Apex Steel Corp., Ltd., Calif
Arwood Corp., NY
Austenal Co., Div. of Howe Sound Co., NY
Baldwin-Lima-Hamilton Corp., Pa
Beaver Valley Alloy Foundry Co., Pa
Bethlehem Steel Co., Pa
Blaw-Knox Co., Pa
Bone Engineering Corp., Calif
Bonney-Floyd Co., Ohio
Brinkerhoff Brass & Bronze Works, Inc., NY
Calorizing Co., Pa
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Commercial Steel Casting Co., Ohio
Copper Alloy Corp., NJ
Crucible Steel Casting Co., Pa
Curtiss-Wright Corp., Metals Processing Div., NY
Dodge Steel Co., Pa
Donegal Steel Foundry Co., Pa
Duraloy Co., Pa —Ad p 429
Duriron Co., Inc., Ohio
Electro-Alloys Div., American Brake Shoe Co., Ohio
Empire Steel Castings, Inc., Pa
Engineered Castings Div., American Brake Shoe Co., NY
Esco Corp., Ore
Fahralloy Co., Ill
Fort Pitt Steel Casting Div., Pittsburgh Steel Foundry Corp., Pa
Frasse, Peter A. & Co., Inc., NY
General Alloys Co., Mass
General Electric Co., Foundry Dept., NY

General Electric Co., Metallurgical Products Dept., Mich
Goslin Birmingham Mfg. Co., Inc., Ala.
Grede Foundries, Inc., Wis
Hanford Foundry Co., Calif
Hartford Electric Steel Corp., Conn
Hica, Inc., La
Hitchiner Mfg. Co., Inc., NH
Howard Foundry Co., Ill
Humphrey Castings, Inc., Calif
Illinois Precise Casting Co., Ill
Industrial Stainless Steels, Inc., Mass
Ingersoll-Rand Co., NJ
Janney Cylinder Co., Pa
Jessop Steel Co., Pa
Johnson, A. & Co., Inc., NY
Jones & Laughlin Steel Corp., Strip Steel Div., Ohio (dd)
Kay-Brunner Steel Products, Inc., Calif
Kolcast Industries Div., Thompson Products, Inc., Ohio
LFM Mfg. Co., Inc., Sub. of Rockwell Mfg. Co., Kan
Lebanon Steel Foundry, Pa
Los Angeles Steel Casting Co., Calif
Manco Products, Inc., Mich
Massillon Steel Casting Co., Ohio
Michigan Steel Casting Co., Div. of Consolidated Foundries & Mfg. Corp., Mich
Midwest Precision Castings Co., Ohio
Minneapolis Electric Steel Castings Co., Minn.
Misco Precision Casting Co., Mich
National Malleable & Steel Castings Co., Ohio
National Precision Casting Corp., Div. of Beryllium Corp., Pa
National Supply Div., Armco Steel Corp., Pa
Ohio Steel Foundry Co., Ohio
Oklahoma Steel Castings Div., American Steel & Pump Corp., Okla.
Perfecto Cast, Calif
Picco, Inc., Calif
Pittsburgh Steel Foundry Corp., Pa
Precision Founders, Inc., Calif
Quaker Alloy Casting Co., Pa
Rockwell Engineering Co., Ill
Ross-Meehan Foundries, Tenn
St. Louis Steel Casting, Inc., Mo
Sandusky Foundry & Machine Co., Ohio
Sharpsville Steel Fabricators, Inc., Pa
Sivyer Steel Casting Co., Wis
Sherwatt Equipment & Mfg. Co., Inc., NY (ff)
Stainless Foundry & Engineering, Inc., Wis
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa
Stanwood Corp., Ill
Star Heel Plate Co., Inc., NJ
Superior Foundry, Inc., Ohio
Symington Div., Symington Wayne Corp., NY
Texas Foundries, Inc., Tex
Texas Steel Co., Tex.
Thompson Products, Inc., Valve Div., Ohio
Union Iron Works, Wash
U.S. Magnet & Alloy Corp., NJ
U.S. Pipe & Foundry Co., Ala
Unitcast Corp., Ohio
Uniworld Research Corp. of America, Ohio
Utility Steel Foundry, Calif
Vanadium-Alloys Steel Co., Pa
Viking Pump Co., Iowa
Vollrath Co., Contract Div., Wis
Wall Colmonoy Corp., Mich
West Steel Casting Co., Ohio
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
Wisconsin Centrifugal Foundry, Inc., Wis

Steel, Low Alloy

Acme Tube, Inc., NJ (ee)
Acme-Newport Steel Co., Ky (z,cc,ee)
Advance Screw Products Co., Inc., Wis
Advance Stamping Co., Mich (dd)
Alan Wood Steel Co., Pa (z,cc,dd)
Alco Products, Inc., NY (q,aa)
Allegheny Ludlum Steel Co., Pa (o,q,w,z,bb,cc,dd,ee,ff)
Alloy Metal Products, Inc., Iowa (o,q,w)
Alofs Mfg. Co., Mich (cc,dd,ff)
Amalgamated Steel Corp., Ohio (o,bb)
American Cast Iron Pipe Co., Ala (ee)
American Steel & Wire Div., U.S. Steel Corp., Ohio
(o,dd)—Ad pp 90-91
Anchor Drawn Steel Co., Div. of Vanadium-Alloys Steel Co., Pa (bb,ff)
Arcos Corp., Pa (ff)
Aristoloy Steel Div., Copperweld Steel Co., Ohio (o,q)
Armco Steel Corp., Ohio (z,cc,dd)
Armco Steel Corp., Sheffield Div., Mo (o,q,w,z,bb,cc,ff)
Arrow Metal Products Corp., NJ (cc)
Atlantic Steel Co., Ga (o)
Austenal Co., Div. of Howe Sound Co.,
Babcock & Wilcox Co., Tubular Products Div., Pa (ee)
Bethlehem Steel Co., Pa (o,q,z,bb,cc,dd,ee,ff)
Biddle Screw Products Co., Ind (o,bb,ee)
Bliss & Laughlin, Inc., Ill (o)
Burkhardt Steel Co., Colo (o,z,cc,dd)
Byers, A.M. Co., Pa (o,q,w,z)
California Metal Enameling Co., Calif (cc)
Cannon-Muskegon Corp., Mich (w)
Carpenter Steel Co., Pa (o,q,w,bb,dd,ff)
Castle, A.M. & Co., Ill (o,q)
Central Steel & Wire Co., Ill (o,z,cc)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (o,q,w,z,bb,cc,ff)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (o,q,w,z,cc,dd,ee)
Connors Steel Div., H.K. Porter Co., Inc., Ala (o,q)
Crucible Steel Co. of America, Pa
(o,q,w,z,bb,cc,dd,ee,ff)—Ad p 89
Curtiss-Wright Corp., Metals Processing Div., NY (ee)
Dixon Sintaloy, Inc., Conn (o)
Dudek & Bock Spring Mfg Co., Ill (dd,ff)
Eastern Rolling Mills, Inc., NY (cc,dd)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (z,cc)
Enterprise Wheel & Car Corp., Va (z,cc)
Eynon-Dakin Co., Mich (ee)
Falk Corp., Wis
Finkl, A. & Sons Co., Ill (w)
Frasse, Peter A. & Co., Inc., NY (o,z,bb,cc,dd,ee,ff)
Great Lakes Steel Corp., Div. of National Steel Corp., Mich (o,z,cc,dd)
Green River Steel Corp., Ky (o,q,w)
Hardy, Charles, Inc., N (aa)
Hayden Wire Works, Inc., Mass (o,bb,ff)
Haydon Corp., NY (ee)
Higbie Mfg. Co., Mich (ee)
Hoeganaes Sponge Iron Corp., NJ (aa)
Inland Steel Co., Ill (o,z,cc,dd)
Jones & Laughlin Steel Corp., Pa (o,q,z,bb,cc,dd,ee,ff)
Kaiser Steel Corp., Calif (o,q,w,z,bb,cc,dd)
Kelsey-Hayes Co., Mich (o,q,z,cc)
Keystone Drawn Steel Co., Pa (q)
Kinkead Industries, Inc., Ill (cc,dd)
Kwikset Powdered Metal Products, Calif (aa)
Larson, Charles E. & Sons Inc., Ill (o)
La Salle Steel Co., Ill (o)
Latrobe Steel Co., Pa (o,q,w)
LeTourneau, R.G., Inc., Tex (z)
Levinson Steel Co., Pa (cc)
Lincoln Steel Corp., Neb (cc)
Lukens Steel Co., Pa (w,z)
Lundquist Tool & Mfg. Co., Inc., Mass (cc,dd)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,dd,ee)
McInnes Steel Co., Pa (o)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Michigan Seamless Tube Co., Mich (ee)
Midvale-Heppenstall Co., Pa (w)
Murray, A.B. Co., Inc., NJ (ee)
National Tube Div., U.S. Steel Corp., Pa (ee)
National-Standard Co., Mich (ff)
National-U.S. Radiator Corp., Plastic Metals Div., Pa (aa)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb)
Northwestern Steel & Wire Co., Ill (o,q,w,z,bb,ff)
Ohio Seamless Tube Div., Copperweld Steel Co., Ohio (ee)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (ff)
Pencoyd Steel & Forge Corp., Pa (o,q,w)
Peninsular Steel Co., Mich (o,q,z)
Phoenix Steel Corp., NY (z)
Pittsburgh Forgings Co., Mich (o,q)
Rathbone Corp., Mass (o,bb)
Reliance Div., Eaton Mfg. Co., Ohio (o,ff)
Republic Steel Corp., Ohio (o,q,w,z,bb,cc,dd,ee,ff)
Republic Supply Co. of California (o,ee)
Revere Copper & Brass, Inc., NY (ee)
Rome Mfg. Div., Revere Copper & Brass, Inc., NY (ee)
Ross-Meehan Foundries, Tenn (o)
Ryerson, Joseph T. & Son, Inc., Ill (o,z,bb,cc,dd,ee)
St. Louis Steel Casting, Inc., Mo (n)
Sandusky Foundry & Machine Co., Ohio (ee)
Sandvik Steel, Inc., NJ (dd)
Sawhill Tubular Products, Inc., Pa (ee)
Scudder, E.J. Foundry & Machine Co., NJ (bb,ee)
Service Steel Div., Van Pelt Corp., Mich (ee)
Sharon Steel Corp., Pa (q,w,z,cc,dd)
Simonds Saw & Steel Co., Mass (o,cc)
Smith-Moon Steel Co., Inc., Kan (o,z,cc)
Solar Steel Corp., Ohio (c,z)
Stainless and Strip Div., Jones & Loughlin Steel Corp., Ohio (dd)
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (q,w)
Star Heel Plate Co., Inc., NJ (ee,ff)
Sun Steel Co., Ill (o,q,z,bb,cc,dd)
Superior Drawn Steel Co., Pa (o,bb,ff)
Superior Tube Co., Pa
(ee)—Ad pp 424-425
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (o,q,w,z,cc,dd,ee)
Thomas Strip Div., Pittsburgh Steel Co., Pa (dd)
Thompson Wire Co., Mass (dd)
Timken Roller Bearing Co., Steel & Tube Div., Ohio (o,q,ee)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Uddeholm Co. of America, Inc., NY (bb)
Ullmann, Inc., Wis (o,ee)
Union Iron Works, Wash (cc)
Union Steel Corp., NJ (dd)
United Screw & Bolt Corp., Ill (bb,cc,dd,ff)
U.S. Steel Corp., Pa (o,q,w,z,cc,dd)
U.S. Steel Supply Div., U.S. Steel Corp., Ill (o,z,cc,dd,ee)
Vanadium-Alloys Steel Co., Pa (o,q,w,z,aa,bb,cc,ee,ff)
Washburn Wire Co., Phillipsdale Div., RI (q,bb,dd)
Weirton Steel Co., Div. of National Steel Corp., W.Va (cc)
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (o)
Wheelock, Lovejoy & Co., Inc., Mass (o,q,bb)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (q,w,ff)
Wilder Mfg. Co., Inc., Calif (o,z,cc)
Wyckoff Steel Co., Pa (o,z)
Youngstown Sheet and Tube Co., Ohio (o,z,cc,dd,ee)

Steel, Low Alloy —Castings

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Adirondack Steel Casting Co., NY
Advance Foundry Co., Ohio
Allied Steel Castings Co., Ill
All-Metals Precision Casting Corp., NY
Alloy Cast Steel Co., Ohio
Alloy Precision Castings Co., Ohio
Alloy Steel & Metals Co., Calif
American Cast Iron Pipe Co., Ala
American Manganese Steel Div., American Brake Shoe Co., Ill
American Steel Foundries, Ill
Arwood Corp., NY
Atlantic Foundry Co., Ohio
Atlantic Steel Castings Co., Pa
Austenal Co., Div. of Howe Sound Co., NY

KEY

MATERIALS

a—Aluminum and its alloys	e—Magnesium and its alloys	j—Zinc and its alloys
b—Copper and its alloys	f—Nickel and its alloys	k—Thermoplastics
c—Iron and its alloys (except steel)	g—Steels	l—Thermosetting plastics
d—Lead and its alloys	h—Titanium and its alloys	m—Elastomers

BASIC FORMS

n—Anodes	r—Custom formed parts (incl. specialties)	v—Foil	aa—Powder
o—Bar	s—Fibers	w—Ingot	bb—Rod
p—Base resins, polymers or gums	t—Film	x—Laminating, casting resins	cc—Sheet
	u—Foams (component materials or products)	y—Molding compounds	dd—Strip
q—Billets		z—Plate	ee—Tubing
			ff—Wire

Auto Specialties Mfg. Co., Mich
Baldwin-Lima-Hamilton Corp., Pa
Bay City Electric Steel Casting Co., Mich
Beaver Valley Alloy Foundry Co., Pa
Bethlehem Steel Co., Pa
Birdsboro Steel Foundry & Machine Co., Pa
Blaw-Knox Co., Pa
Bone Engineering Corp., Calif
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Commercial Steel Casting Co., Ohio
Crucible Steel Casting Co., Pa
Dayton Steel Foundry Co., Ohio
Dodge Steel Co., Pa
Electric Steel Castings Co., Ind
Electrocast Steel Foundry Co., Ill
Empire Foundry Co., Inc., Calif
Empire Steel Castings, Inc., Pa
Esco Corp., Ore
Federal Steel Products Corp., Tex
General Electric Co., Foundry Dept., NY
General Steel Castings Corp., Ill
Glover Machine Works, Ga
Goslin Birmingham Mfg. Co., Inc., Ala
Grafton Foundry Co., Wis
Grede Foundries, Inc., Wis
Gunite Foundries Corp., Ill
Hartford Electric Steel Corp., Conn
Hica, Inc., La
Hitchiner Mfg. Co., Inc., NH
Howard Foundry Co., Ill
Hughes Tool Co., Tex
Humphrey Castings, Inc., Calif
Illinois Precise Casting Co., Ill
Kay-Brunner Steel Products, Inc., Calif
Kolcast Industries Div., Thompson Products, Inc., Ohio
Kwikset Powdered Metal Products, Calif
Lebanon Steel Foundry, Pa
Lectromelt Casting Div., Akron Standard Mold Co., Ohio
Los Angeles Steel Casting Co., Calif
Mackintosh-Hemphill Div., E.W. Bliss Co., Pa
Massillon Steel Casting Co., Ohio
Metropolitan Iron Foundry, NY
Midwest Precision Castings Co., Ohio
Minneapolis Electric Steel Castings Co., Minn
Misco Precision Casting Co., Mich
Missouri Steel Castings Co., Mo
Monroe Steel Castings Co., Mich
National Malleable & Steel Castings Co., Ohio
National Precision Casting Corp., Div of Beryllium Corp., Pa
National Supply Div., Armco Steel Corp., Pa
Ohio Steel Foundry Co., Ohio
Oklahoma Steel Castings Div., American Steel & Pump Corp., Okla
Olympic Steel Works, Wash
Omaha Steel Works, Neb
Pelton Steel Casting Co., Wis
Picco, Inc., Calif
Pittsburgh Steel Foundry Corp., Pa
Pratt & Letchworth Div., Dayton Malleable Iron Co., Inc., NY
Precision Founders, Inc., Calif
Quaker Alloy Casting Co., Pa
Quality Electric Steel Castings, Inc., Tex
Racine Steel Castings Co., Belle City Malleable Div., Wis
Reliance Steel Castings Co., Pa
Rockwell Engineering Co., Ill
Ross-Meehan Foundries, Tenn
St. Louis Steel Casting, Inc., Mo
Sandusky Foundry & Machine Co., Ohio
Sawbrook Steel Castings Co., Ohio
Scudder, E.J. Foundry & Machine Co., NJ
Sharpsville Steel Fabricators, Inc., Pa
Sivyer Steel Casting Co., Wis
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa
Star Heel Plate Co., Inc., NJ
Strong Steel Foundry Co., NY
Superior Foundry, Inc., Ohio
Swedish Crucible Steel Co., Mich
Symington Div., Symington Wayne Corp., NY
Taylor-Wharton Co., Div. of Harsco Corp., NJ
Texas Foundries, Inc., Tex
Texas Steel Co., Tex
Union Iron Works, Wash
Union Spring & Mfg. Co., Pa
Unitcast Corp., Ohio
United Shoe Machinery Corp., Mass
U. S. Magnet & Alloy Corp., NJ
U.S. Pipe & Foundry Co., Ala
Utility Steel Foundry, Calif
Valley Steel Casting Co., Mich
Vanadium-Alloys Steel Co., Pa
Viking Pump Co., Iowa
Vulcan Iron Works, Pa
Washington Iron Works, Wash
West Steel Casting Co., Ohio
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
Westlectric Castings, Inc., Calif
Westmoreland Malleable Iron Co., NY
Worthington Corp., NJ

Steel, Specialty

(electrical, magnet, nitriding, etc.)

Acme-Newport Steel Co., Ky (cc)
Adirondack Steel Casting Co., NY
Allegheny Ludlum Steel Corp., Pa (o,q,z,bb,ff)
Alloy Metal Powders, Inc., NY (aa)
Amalgamated Steel Corp., Ohio (o,bb)
American Silver Co., Inc., NY (v, bb, ee,ff)
Armco Steel Corp., Ohio (o,q,v,z,bb,cc,dd,ee,ff)
Arnold Engineering Co., Ill (dd)
Atlantic Steel Co., Ga (o)
Austenal Co., Div. of Howe Sound Co., NY (w)
Bethlehem Steel Co., Pa (o,q)
Biddle Screw Products Co., Ind (o,bb,ee)
Bishop, J. & Co. Platinum Works, Pa (ee)
Brush Beryllium Co., Ohio (v,dd)
Byers, A. M. Co., Pa (q,z)
Cannon-Muskegon Corp., Mich (w,ff)
Carpenter Steel Co., Pa (o,q,w,bb,dd,ee)
Chicago Development Corp., Md (aa)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (o,q,w,z,bb,cc,ff)
Crucible Steel Co. of America, Pa
(o,q,w,z,bb,cc)—Ad p 89
Edgcomb Steel & Aluminum Corp., NJ (o,cc,dd)
Firth Sterling Inc., Pa (o,q,w,bb,ff)
Green River Steel Corp., Ky (o,q,w)
Hamilton Watch Co., Precision Metals Div., Pa (v,cc,dd,ff)
Hoeganaes Sponge Iron Corp., NJ
(aa)—Ad p 428
Inland Steel Co., Ill (cc)
Jessop Steel Co., Pa
Johnston & Funk Titanium Corp., Ohio (w,bb,ff)
Jones & Laughlin Steel Corp., Pa (o,z,cc)
Kassel Export Co., Inc., NJ (dd,ff)
Kelsey-Hayes Co., Metals Div., NY (o,q,w,z,bb,cc,dd,ff)
Kwikset Powdered Metal Products, Calif (aa)
Larson Tool & Stamping Co., Mass (o)
La Salle Steel Co., Mo (o)
Latrobe Steel Co., Pa (o,q,w)
Lukens Steel Co., Pa (w,z)
Manganese Steel Forge Co., Pa (o,z,bb,cc,dd,ff)
McInnes Steel Co., Pa (o)
Midvale-Heppenstall Co., Pa (q,w)
National Supply Div., Armco Steel Corp., Pa (o,q,w)
National-Standard Co., Mich (dd,ff)
Phoenix Steel Corp., NY (z)
Reactive Metals, Inc., Ohio (cc)
Republic Steel Corp., Ohio (o,q,w,z,bb,cc,dd,ee)
Ryerson, Joseph T. & Son, Inc., Ill (o)
Sandvik Steel, Inc., NJ
(o,bb,dd)—Ad p 93
Sharon Steel Corp., Pa (cc)
Simonds Saw and Steel Co., Mass (cc, dd)
Stulz-Sickles Co., NJ (o,q,z,bb)
Superior Steel Corp., Pa (dd)
Sylvania Electric Products Inc., Parts Div., Pa (ff)
Timken Roller Bearing Co., Steel & Tube Div., Ohio (o,q,ee)
Ullmann, Inc., Wis (o,ee)
Universal-Cyclops Steel Corp., Pa (o,q,z,bb,cc,dd,ff)
Vanadium-Alloys Steel Co., Pa (o,q,w,z,aa,bb,cc,ee,ff)
Vascoloy-Ramet Corp., Ill
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd,ee)

Steel, Specialty —Castings

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Allegheny Ludlum Steel Corp., Pa
All-Metals Precision Casting Corp., NY
Alloy Precision Castings Co., Ohio
American Brake Shoe Co., NY
American Steel Foundries, Ill
Arwood Corp., NY
Austenal Co., Div. of Howe Sound Co., NY
Baldwin-Lima-Hamilton Corp., Pa
Beaver Valley Alloy Foundry Co., Pa
Bethlehem Steel Co., Pa
Blaw-Knox Co., Pa
Bone Engineering Corp., Calif
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Crobalt, Inc., Mich
Crucible Steel Casting Co., Pa
Curtiss-Wright Corp., Metals Processing Div., NY
Esco Corp., Ore
General Electric Co., Foundry Dept., NY
General Steel Castings Corp., Ill
Grede Foundries, Inc., Wis
Hica, Inc., La
Howard Foundry Co., Ill.
Humphrey Castings, Inc., Calif
Janney Cylinder Co., Pa
Johnston & Funk Titanium Corp., Ohio
Kay-Brunner Steel Products, Inc., Calif
Kolcast Industries, Div., Thompson Products, Inc., Ohio
LFM Mfg. Co., Sub. of Rockwell Mfg. Co., Kan
Lebanon Steel Foundry, Pa
Los Angeles Steel Casting Co., Calif
Manco Products, Inc., Mich
Midwest Precision Castings Co., Ohio
Misco Precision Casting Co., Mich
Missouri Steel Castings Co., Mo
National Precision Casting Corp., Div. of Beryllium Corp., Pa
National Supply Div., Armco Steel Corp., Pa
Ohio Steel Foundry Co., Ohio
Overmyer Mould Co., Inc., Ind
Perfecto Cast, Calif
Picco, Inc., Calif
Precision Founders, Inc., Calif
Quaker Alloy Casting Co., Pa
Quality Electric Steel Castings, Inc., Tex
Rockwell Engineering Co., Ill
Scullin Steel Co., Mo
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa
Star Heel Plate Co., Inc., NJ
Stulz-Sickles Co., NJ
Swedish Crucible Steel Co., Mich
Symington Div., Symington Wayne Corp., NY
Taylor-Wharton Co., Div. of Harsco Corp., NJ
Texas Foundries, Inc., Tex
United Shoe Machinery Corp., Mass
U.S. Magnet & Alloy Corp., NJ
U.S. Pipe & Foundry Co., Ala
Uniworld Research Corp. of America, Ohio
Utility Steel Foundry, Calif
Vanadium-Alloys Steel Co., Pa
Wall Colmonoy Corp., Mich
Washington Iron Works, Wash
West Steel Casting Co., Ohio
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
Wisconsin Centrifugal Foundry, Inc., Wis

Steel, Tool and Die

Able Tool & Engineering Co., Ill (z)
Advance Stamping Co., Mich (o,z,bb)
Albraco Metals Corp., NY (o,q,bb)
Allegheny Ludlum Steel Corp., Pa (o,q,z,bb,ff)
Alofs Mfg. Co., Mich (o,z,bb)
Amalgamated Steel Corp., Ohio (o,bb)
American Brake Shoe Co., NY (aa)
Anchor Drawn Steel Co., Div. of Vanadium Alloys Steel Co., Pa (bb,ff)
Austenal Co., Div. of Howe Sound Co., NY (w)
Bethlehem Steel Co., Pa (o,q)
Biddle Screw Products Co., Ind (o,bb,ee)
Braeburn Alloy Steel Corp., Pa (o,q)
Cannon-Muskegon Corp., Mich (w)
Carpenter Steel Co., Pa (o,q,w,bb,dd,ff)
Central Steel & Wire Co., Ill (o)
Columbia Tool Steel Co., Ill (o,q,w,bb)
Crucible Steel Co. of America, Pa
(o,q,w,z,bb,cc,ff)—Ad p 89
Delaware Tool Steel Corp., Del (o)
Edgcomb Steel & Aluminum Corp., NJ (o,q,w,bb)
Finkl, A. & Sons Co., Ill (w)
Firth Sterling, Inc., Pa (o,q,w,bb,ff)
Forg, Peter Mfg. Co., Mass (cc)
Frasse, Peter A. & Co., Inc., NY (o)
Green River Steel Corp., Ky (o,q,w)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (o,z,bb)
Heller Tool Co., Ohio (o)
Inshield Die & Stamping Co., Ohio (o)
Jessop Steel Co., Pa (o,q,z,cc,dd)
Jones & Laughlin Steel Corp., Pa (o,z,bb)
Kinkead Industries, Inc., Ill (o,z,bb)
Larson, Charles E. & Sons, Inc., Ill (o)
Latrobe Steel Co., Pa (o,q,w)
Lundquist Tool & Mfg. Co., Inc., Mass (o,z,bb)
Midvale-Heppenstall Co., Pa (q,w)
Morrisville Foundry Co., Inc., Vt (bb)
National Supply Div., Armco Steel Corp., Pa (o,q,w)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Norwalk Powdered Metals, Inc., Conn (aa)
Ormond Mfg., Co., Inc., NJ (cc,dd,ff)
Pencoyd Steel & Forge Corp., Pa (o,q,w)
Peninsular Steel Co., Mich (o,q,z)
Pittsburgh Tool Steel Wire Co., Pa (o,bb)
Republic Steel Corp., Ohio (o,q)
Ross-Meehan Foundries, Tenn (o)
Ryerson, Joseph T. & Son, Inc., Ill (o,bb,cc)
Simonds Saw & Steel Co., Mass (o,cc)
Solar Steel Corp., Ohio (o,bb)
Superior Tube Co., Pa (ee)
Temescal Metallurgical Corp., Calif (o,q,w,z)
Timken Roller Bearing Co., Steel & Tube Div., Ohio (o,q)
Uddeholm Co. of America, Inc., NY (o,q)
Universal-Cyclops Steel Corp., Pa (o,q,z,bb,cc,dd,ff)
Vanadium-Alloys Steel Co., Pa
(o,q,w,z,aa,bb,cc,ee,ff)—Ad p 88
Vulcan-Kidd Steel Div., H.K. Porter Co. Inc., Pa (o,q,w,bb,ff)
Waimet Alloys Co., Mich (w)
Wheelock, Lovejoy & Co., Inc., Mass (o,q,bb)

Wilder Mfg. Co., Inc., Calif (o,bb)
Ziv Steel & Wire Co., Ill (o,q)

Steel, Tool and Die—Castings

Albraco Metals Corp., NY
Allegheny Ludlum Steel Corp., Pa
All-Metals Precision Casting Corp., NY
Alloy Precision Casting Co., Ohio
American Foundry & Machine Div., Elmco Corp., Utah
Apex Steel Corp., Ltd., Calif
Arwood Corp., NY
Atlantic Steel Castings Co., Pa
Austenal Co., Div of Howe Sound Co., NY
Bay City Electric Steel Casting Co., Mich
Beaver Valley Alloy Foundry Co., Pa
Bone Engineering Corp., Calif
Carondelet Foundry Co., Mo
Crucible Steel Co. of America, Pa
Curtiss-Wright Corp., Metals Processing Div., NY
Empire Steel Castings, Inc., Pa
General Electric Co., Foundry Dept., NY
Hica, Inc., La
Hitchiner Mfg. Co., Inc., NH
Howard Foundry Co., Ill
Illinois Precise Casting Co., Ill
Janney Cylinder Co., Pa
Kolcast Industries Div., Thompson Products Inc., Ohio
LFM Mfg. Co., Sub. of Rockwell Mfg. Co., Kan
Lebanon Steel Foundry, Pa
Manco Products, Inc., Mich
Midwest Precision Castings Co., Ohio
Misco Precision Casting Co., Mich
Missouri Steel Castings Co., Mo
National Precision Casting Corp., Div. of Beryllium Corp., Pa
National Supply Div., Armco Steel Corp., Pa
Precision Founders, Inc., Calif
Quaker Alloy Casting Co., Pa
Rockwell Engineering Co., Ill
Ross-Meehan Foundries, Tenn
Star Heel Plate Co., Inc., NJ
Swedish Crucible Steel Co., Mich
Vanadium-Alloys Steel Co., Pa
Westinghouse Electric Corp., Materials Mfg. Dept., Pa

Strip
(see specific material)

Strippable Coatings
(see Organic Coatings)

Styrene
(see Polystyrene)

Styrene-Butadiene Rubber

Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,cc,dd,ee)
American Synthetic Rubber Corp., NY (p)
Anderson Assoc., Inc., Ohio (y)
Auburn Plastics, Inc., NY (bb,cc,dd)
Auburn Rubber Co., Inc., Ind (cc)
Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Bond International, Inc., Mich (y,ee)
Borden Co., Borden Chemical Div., NY (p)
Buffalo Weaving & Belting Co., NY (cc)
Capac Mfg. Corp., Mich (y,cc)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Ill (p)
Colonial Rubber Corp., Ohio (y,cc)—Ad p 416
Continental Rubber Works, Pa (bb,cc,dd,ee)
Copolymer Rubber and Chemical Corp., La (p)
Dayton Rubber Co., Ohio (y,bb,cc,dd,ee)
Dewey & Almy Chemical Div., W. R. Grace & Co., Mass (p)
Dow Chemical Co., Plastic Div., Mich
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
Dyna-Therm Chemical Corp., Calif (p)
Electrofilm, Inc., Calif (t)
Faultless Rubber Co., Ohio (u,y,bb,ee)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (u,y,cc,ee)
Firestone Tire & Rubber Co., Ohio (p)
Garlock Packing Co., NY (y,bb,cc,dd,ee)
Geauga Industries Co., Ohio (y,bb,dd)
General Tire & Rubber Co., Chemical Div., Ohio (p)
Goodrich, B.F. Chemical Co., Ohio (p,cc)
Goodrich-Gulf Chemicals Inc., Ohio (p)
Goodyear Tire & Rubber Co., Chemical Div., Ohio (p)
Goshen Rubber Co., Inc., Ind (y)
Rubber Corp. of America, NY
Heresite & Chemical Co., Wis (p)
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd)
Koppers Co., Inc., Pa (p)
Maloney, F.H. Co., Tex (y)
Marbon Chemical Div., Borg-Warner Corp., Ind (p,u,x,y)
Martin Rubber Co., Inc., NJ (y,dd,ee)
Mid-States Rubber Products, Inc., Ind (y)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,u,x,y)
Paeco Rubber Co., Inc., Ohio (y,dd,ee)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (y)
Parker, Stearns & Co., Inc., NY (cc,dd)
Phillips Chemical Co., Okla (p)
Polymer Chemical Co., Ohio (x)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p,y,cc,dd,ee)
Roberts Toledo Rubber Co., Ohio (ee)
Roth Rubber Co., Ill (y,cc)
Rubatex Div., Great American Industries Inc., Va (u)
Rubber Corp. of America, NY
Shell Chemical Co., NY (p)
Sheller Mfg. Corp., Mich (u)
Southern Plastics Co., SC (bb,cc,dd,ee)
Sperry Rubber & Plastics Co., Ind (dd,ee)
Stockwell Rubber Co., Inc., Pa (y,bb,cc,dd)
Technical Specialties Co., NY (dd)
Texas-U.S. Chemical Co., Tex (p)
Toyad Corp., Pa (u)
Trostel, Albert Packing, Ltd., Wis (y)
United Rubber & Chemical Co., Tex (p)
U.S. Rubber Co., NY (p)
U.S. Rubber Co., Kem-Blo Dept., Conn (u)
Vulcan Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Felt Works, Ill (y,cc,dd,ee)
Westlake Plastics Co., Pa (t,bb,cc,dd)
Williams-Bowman Rubber Co., Ill (y,bb,cc)

Superalloys
(see Nickel; Cobalt; Chromium)

Synthetic Fibers
(see specific polymer)

Tantalum and Its Alloys

Alpha Metals, Inc., NJ (v,cc,dd)
American Silver Co., NY (v,dd,ee,ff)
Belmont Smelting & Refining Works, Inc., NY (aa)
Bishop, J. & Co. Platinum Works, Pa (ee)
Damascus Tube Co., Pa (ee)
Esco Corp., Ore
Fansteel Metallurgical Corp., Ill (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff) — Ad pp 161-164
Firth Sterling Inc., Pa (q,aa)
Foote Mineral Co., Pa (aa)
Hamilton Watch Co., Precision Metals Div., Pa (v,dd)
Hardy, Charles, Inc., NY (aa)
Harvey Aluminum, Calif (o,bb)
Haynes Stellite Co., Div. of Union Carbide Corp., NY (o,v,bb,cc,dd,ee,ff)
Hoskins Mfg. Co., Mich (ff)
Industrial Techtronics Inc., Mich
Johnston & Funk Titanium Corp., Ohio (bb,ff)
Kawecki Chemical Co., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Kennametal, Inc., Pa (o,v,aa,dd,ff)—Ad p 323
Linde Co. Div., Union Carbide Corp., NY
Metals & Residues, Inc., NJ (aa)
National Research Corp., Mass (v,w,aa,bb,cc,ee,ff)
Nuclear Materials & Equipment Corp., Pa (o,w,aa,bb)
Nuclear Metals, Inc., Mass (w,bb,dd,ee)
Oregon Metallurgical Corp., Ore (w)
Plasmadyne Corp., Calif (aa)
Schwarzkopf Development Corp., NY (aa,bb,cc,dd,ee,ff)
Shieldalloy Corp., NJ (w,aa)
Superior Tube Co., Pa (ee)—Ad pp 424-425
Temescal Metallurgical Corp., Calif (o,q,w,z)—Ad p 167
Texas Instruments, Inc., Metals & Controls Div., Mass (v,dd,ff)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (w,aa)
Universal Cyclops Steel Corp., Pa (o,q,z,cc)
Vacuum Technology, Inc., Calif (cc,dd)
Vascoloy-Ramet Corp., Ill
Wah Chang Corp., NY (v,aa,bb,dd,ff)—Ad p 152
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd,ee)
Wolverine Tube Div., Calumet & Hecla, Inc., Mich (ee)

Tapes, Adhesive

American Tape Co., Mich
Armstrong Cork Co., Pa
Avery Label Co., Calif
Angier Adhesives Div., Interchemical Corp., Mass
Atlantic Bag Co., NY
Beck, I. & Sons, Inc., NY
Coating Products, Inc., NJ
Connecticut Hard Rubber Co., Conn
Cycleweld Div., Chrysler Corp., Mich
Dodge Fibers Corp., NY
Durable Rubber Products Co., Ill
Dutch Brand Div., Johns-Manville Corp., Ill
Electro Technical Div., Sun Chemical Corp., NJ
Enflo Corp., NJ
Foamade Industries, Mich
Foss Mfg. Co., Id
Hampton Mfg. Co., NY
Hiller Aircraft Corp., Adhesive Engineering Div., Calif
Insulation Mfrs. Corp., Ill
Interchemical Corp., NY
Interchemical Corp., Finishes Div., NJ
Johns-Manville Corp., NY
Kinkead Industries, Inc., Ill
Lundquist Tool & Mfg. Co., Inc., Mass
Moxness Products, Inc., Wis—Ad p 302
Mystik Adhesive Products, Inc., Ill
Narmco Industries, Inc., Narmco Materials Div., Calif
Nicolet Industries, Inc., NY
Permacel, NJ
Presstite Div., American-Marietta Co., Mo
Respro Div., General Tire & Rubber Co., RI
Reynolds Aluminum Supply Co., Ga
Royston Laboratories, Inc., Pa
Rubber & Plastics Compound Co., Inc., NY
Superior Plastics, Inc., Ill
Technical Tape Corp., NY

Teflon
(see Fluorocarbons)

Terne Plate
(see Precoated Metals)

Tetrafluoroethylene
(see Fluorocarbon)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Tin and Its Alloys

African Metals Corp., NY (w)
Allied Research Products, Inc., Md (n)
Alpha Metals, Inc., NJ (n,o,q,v,w,aa, bb,cc,dd)
American Metal Climax, Inc., NY (w,aa)
American Smelting & Refining Co., NY (n,o,w)
Anchor Metal Co., Inc., NY (w,aa)
Arcos Corp., Pa (ff)
Avril, G. A. Co., Ohio (n,o,q,ee,ff)
Belmont Smelting & Refining Works, Inc., NY (n,o,v,w,aa,cc,dd,ff)
Caspers Tin Plate Co., Ill (cc,dd)
Cerro Sales Corp., Sub. of Cerro Corp., NY
(w)—Ad p 154
Crown Metal Co., Wis (n,ee,ff)
Division Lead Co., Ill (o,v,w,cc,dd,ee, ff)
Dixon Sintaloy, Inc., Conn (o)
Empire Metal Co., NY (n,o,q,w,bb,ff)
Farrelloy Co., Pa (aa,ff)
Glidden Co., Chemical Divs., Metals Dept., Ind
(aa)—Ad p 397
Greenback Industries, Inc., Mich (aa)
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (ff)
Hettleman, K. & Sons, Inc., Md (w)
Hi-Grade Alloy Corp., Ill (n,o,v,w,ee)
Hodgson Foundry Co., Ill (n)
Indium Corp. of America, NY (dd,ff)
Johnston Foil Div., Standard Packaging Corp., Mo (v,cc)
Korhumel Steel and Aluminum Co., Ill (z,dd)
Kwikset Powdered Metal Products, Calif (aa)
McGean Chemical Co., Ohio (n,o,aa)
Metal & Thermit Corp., NJ (n,w,aa)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metals Disintegrating Co. Div., American-Marietta Co., NJ (aa)
Metco Inc., NY (ff)
Modern Plating Corp., Ill (n)
National Lead Co., NY (n,o,q,w,z,aa, bb,cc,dd,ee)
Nesor Alloy Products Co., NJ (ff)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Norwalk Powdered Metals, Inc., Conn (aa)
Pittsburgh Smelting & Refining Co., Pa (o,w)
Presswork, Inc., Mich (cc)
Republic Metals Co., Inc., NY (n,o, v,w,cc,ee,ff)
Revere Copper & Brass, Inc., NY (v)
Revere Copper & Brass, Inc., Foil Div., NY (v)
River Smelting & Refining Co., Ohio (o)
Rotometals, Calif (o,v,w,aa)
Sherwatt Equipment & Mfg. Co., Inc., NY (ff)
Stevens, Frederic B., Inc., Mich (n)
Udylite Corp., Mich (n)
United Refining & Smelting Co., Ill (n,o,q,w,z,bb,cc,dd,ff)

Tinplate

(see Precoated Metals)

Titanium and Its Alloys

Alpha Metals, Inc., NJ (v)
American Nickel Alloy Mfg. Corp., NY (o,bb,cc)
American Silver Co., NY (v,dd,ee,ff)
Belmont Smelting & Refining Works, Inc., NY (aa)
Bishop, J. & Co. Platinum Works, Pa (ee)
Central Fabricators, Inc., Ohio (z,bb, cc,ee)
Chicago Development Corp., Md (o,v,z, aa,bb,cc,dd,ff)
Crucible Steel Co. of America, Pa
(o,q,w,z,bb,cc,dd,ee,ff)—Ad p 89
Damascus Tube Co., Pa (ee)
Driver-Harris Co., NJ (v,dd)
du Pont de Nemours, E. I. & Co., Inc., Del (w)
Esco Corp., Ore (o,q,w,bb,ee)
Foote Mineral Co., Pa (o,bb)
Hardy, Charles, Inc., NY (aa)
Harvey Aluminum, Calif (o,q,w,bb,ee)
Hexcel Products, Inc., Calif (v)
Hoskins Mfg. Co., Mich (ff)
Johnston & Funk Titanium Corp., Ohio (bb,ff)
Kennametal, Inc., Pa (aa,bb,ee)
King Laboratories, Inc., NY (w,aa)
Linde Co., Div. of Union Carbide Corp., NY
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,dd)
Mallory, P.R. & Co., Inc., Ind (o,z, bb,cc,dd,ee)
Metal Forming Corp. Div., Vanadium-Alloys Steel Co., Ind (ee)
Metal Hydrides, Inc., Mass (aa)
Metal & Thermit Corp., NJ (w)
Metals Disintegrating Div., American-Marietta Co., NJ (aa)
Michigan Seamless Tube Co., Mich (ee)
National Lead Co., NY (o,q,w,z,bb,cc, dd,ee,ff)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Nuclear Metals, Inc., Mass (w,bb,dd, ee)
Oregon Metallurgical Corp., Ore (w,ee)
Pioneer Aluminum, Inc., Calif (z)
Plasmadyne Corp., Calif (aa)
Plasmatech Div., Valley Metallurgical Processing Co., Conn (aa)
Reactive Metals, Inc., Ohio (o,q,w,z, bb,cc,dd,ee,ff)
Republic Steel Corp., Ohio (o,q,v,w, z,cc,dd,ee,ff)
Rigidized Metals Corp., NY (cc,dd)
Rodney Metals, Inc., Mass (v,dd)
Shieldalloy Corp., NJ (aa)
Superior Steel Corp., Pa (dd)
Superior Tube Co., Pa
(ee)—Ad pp 424-425
Techalloy Co., Inc., Pa (dd,ff)
Temescal Metallurgical Corp., Calif (o,q,w,z)
Texas Instruments, Inc., Metals & Controls Div., Mass (v,cc,dd)
Titanium Metals Corp. of America, NY (o,q,v,z,aa,bb,cc,dd,ee,ff)
Trent Tube Co., Pa (ee)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Ullmann, Inc., Wis (o,ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
United International Research, Inc., NY (aa)
Vanadium Corp. of America, NY (w)
Vascoloy-Ramet Corp., Ill
Wolverine Tube Div., Calumet & Hecla, Inc., Mich (ee)
Worcester Wire Works Div., National-Standard Co., Mass (ff)
Youngstown Welding & Engineering Co., Ohio (ee)

Tool Steels

(see Steel)

Transfer Moldings

(see Moldings)

Trifluorochloroethylene

(see Fluorocarbon)

Tubing, Pipe

Acadia Synthetic Products Div., Western Felt Works, Ill (k)
Ace Plastic Co., NY (k,l)
Acme Tube, Inc., NJ (a,b)
Acme-Newport Steel Co., Ky (g)
Aerojet-General Corp., Structural Materials Div., Calif (l)
Albert Pipe Supply Co., Inc., NY (a,g,k)
Albright Son & Co., Pa (g)
Allegheny Ludlum Steel Corp., Pa (g)
Allegheny Plastics, Inc., Pa
Allied Tube Corp., Pa (a,g)
Aluminum Co. of America, Pa (a,e)
Amco Plastic Pipe Co., Calif (k)
American Agile Corp., Ohio (k)
American Cast Iron Pipe Co., Ala
(c,f,g)—Ad p 398
American Metal Products Co., Mich (a,g)
American Molding Co., Calif (k)
American Nickel Alloy Mfg. Corp., NY (f)
American Pipe & Construction Co., Ore (g)
American Plastics Corp., NY (k)
American Reed Co., Inc., Mass (a)
American Smelting & Refining Co., NY (d)
American Silver Co., NY (b,f,g,h)
Ampco Metal, Inc., Wis (b)
Anaconda Metal Hose Div., Anaconda American Brass Co., Conn (a,b,g,k)
Anchor Plastics Corp., NY (k)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Argo Plastic Products Co., Ohio (k)
Armco Steel Corp., Ohio (g)
Arvin Industries, Inc., Ohio (a,g)
Atlantic India Rubber Works, Inc., Ill (m)
Atlantic Steel Co., Ga (a,g)
Atlas Mineral Products Co., Pa (k)
Auburn Plastic Engineering, Ill (k)
Avins Industrial Products Corp., NY (c)
Avon Tube Div., Higbie Mfg. Co., Mich (g)
Babcock & Wilcox Co., Tubular Products Div., Pa
(g)—Ad p 423
Badger Aluminum Extrusions, NY (a)
Benada Aluminum Products Co., Ohio (a)
Bethlehem Steel Co., Pa (g)
Bishop, J. & Co. Platinum Works, Pa
(f,g,h)—Ad p 394
Bohn Aluminum & Brass Corp., Mich (a)
Bond International, Inc., Mich (m)
Borden Co., Borden Chemical Div., NY (k)
Brainard Steel Div., Sharon Steel Corp., Ohio (g)
Bridgeport Brass Co., Conn (b,f,h)
Brinkerhoff Brass & Bronze Works, Inc., NY (a,b,f,g)
Broadway Mfg. Co., Wis (c,f,g)
Bundy Tubing Co., Mich (f,g)
Bunker Hill Co., Calif (d)
Burkhardt Steel Co., Colo (g)
Busada Mfg. Corp., NY
(k)—Ad p 415
Byers, A. M. Co., Pa (c,k)
Cadillac Plastic & Chemical Co., Mich (k,l,m)
Calfibe Co., Inc., Calif (k)
Carlon Products Corp., Ohio (k)
Carolina Industrial Plastics Div., Essex Wire Corp., NC (k)
Carpenter Steel Co., Pa (f,g,h)
Carpenter Steel Co., Alloy Tube Div., NJ (g)
Cartwright, R. Tube Products Co., Mich (a,b,e,f,g)
Celluplastic Corp., NJ (k)
Central Steel & Wire Co., Ill (a,b,g)
Channel Master Corp., NY (a)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (a, b,g)
Chicago Gasket Co., Ill (k)
Clayton Mark & Co., Ill (g)
Cleveland Container Co., Ohio (l)
Clifton Conduit Corp., Md (g)
Colonial Alloys Co., Pa (a)
Colonial Plastics Mfg. Co., Div. of Van Dorn Iron Works Co., Ohio (k)
Columbia-Geneva Steel Div., U. S. Steel Corp., Calif (g)
Conneaut Rubber & Plastics Co., Div. of U.S. Stoneware Co., Ohio (k)
Continental Copper & Steel Industries, Inc., NY (a,b,c,e,f,g,h)
Continental Rubber Works, Pa (m)
Continuous Cast Products Dept., American Smelting & Refining Co., NJ (b)
Copper and Brass Sales, Inc., Mich (a,b,e)
Cornell and Underhill, Inc., NJ (a,c,g)
Corson Industries, Pa (a)
Crane Co., Ill (k)
Crane Plastics, Inc., Ohio (k,m)
Crescent Plastics, Inc., Ind (k)
Croname Inc., Ill (a,g)
Crucible Steel Co. of America, Pa (f,g,h)
CrystalX Corp., Pa (k)
Curbell, Inc., NY (k,l,m)
Curtiss-Wright Corp., Metals Processing Div., NY (g,h)
Damascus Tube Co., Pa (f,g,h)
Daubert Chemical Co., Ill (m)
Defiance Metal Products Co., Ohio (g)
Detroit Float & Stamping Co., Mich (b)
Dewitt Plastics, NY (k)
Division Lead Co., Ill (d)
Dixie Aluminum Corp., Ga (a)
Dixie Plastics Mfg. Co., La (k)
Dixon Corp., RI (k)
Doré, John L. Co., Tex (l)
Dormont Mfg. Co., Pa (a,b,c,e)
Dow Chemical Co., Mich (a,e)
Drawn Metal Tube Co., Conn (b)
Dryden Rubber Div., Sheller Mfg. Co., Ill (m)
Easton Plastic Products Co., Inc., Pa (k)
Eclipse Plastic Industries, Inc., Fla (k)
Edgcomb Steel & Aluminum Corp., NJ (a)
Electronic Parts Mfg. Co., Inc., NJ (b,f)
Ellwood City Iron & Wire Co., Pa (c)
Emerson-Sack-Warner Corp., Mass (a, b,f,g)
Empire Metal Co., NY (d)
Esco Corp., Ore (g,h)
Ethylene Chemical Corp., NJ (l)
Evans Metal Co., Ga (d)
Eynon-Dakin Co., Mich (a,b,c,f,g)
Fibercast Co., Div., of Youngstown Sheet and Tube Co., Okla (l)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (m)
FitzSimons Mfg. Co., Mich (g)
Flexaust Co., Div. of Callahan Mining Co., Inc., NY (m)
Flexonics Corp., Ill (g)
Florence Pipe Foundry & Machine Co., NJ (c)
Formed Tubes, Inc., Mich (g)
Fox Products Co., Pa (a)
Frasse, Peter A. & Co., Inc., NY (a,g)
Fromson Orban Co., Inc., NY (a,b,f,g)
Fry Plastics International, Calif (k)
Garlock Packing Co., NY (k)
Gates Rubber Co., Colo (k)
Geauga Industries Co., Ohio (m)
General American Transportation Corp., Plastics Div., Ill
General Extrusions, Inc., Ohio (a)
General Motors Corp., Rochester Products Div., NY
(g)—Ad p 435
Genesee Laboratories, Inc., NY (k)
Gering Plastics, Div. of Studebaker-Packard Corp., NJ (k)
Glass Laboratories, NY (k)
Goodrich, B.F., Industrial Products Co., Ohio (k)
Hadbar, Inc., Calif (k,m)
H & H Tube & Mfg. Co., Mich (b)
H-P Products, Inc., Ohio (g)
H & R Plastics Industries, Inc., Pa (k)
Hall Mfg. Corp., NJ (k)
Hartwell, H.N. & Son, Inc., Mass (k)

Harvey Aluminum, Calif (a,h)

Hawkridge Bros. Co., Mass (a)

Haydon Corp., NY (a,g)

Haynes Stellite Co., Div. of Union Carbide Corp., NY (f)

Hays Mfg. Co., Pa (l)

Hazledine, E.T. Co., Ind (g)

Hell Process Equipment Corp., Ohio (k)

Hi-Grade Alloy Corp., Ill (d)

Houston Blow Pipe & Sheet Metal Works, Tex (a,b,g)

Hungerford Plastics Corp., NJ (k)

Huntington Alloy Products Div., International Nickel Co., Inc., W.Va (f)

Hussey, C.G. & Co., Div. of Copper Range Co., Pa
(b)—Ad p 160

Hydrawlik Co., NJ (k,m)

Imco Container Corp., Mo (k)

Industrial Pipe & Supply Co., Ill (g)

Industrial Plastic Fittings Co., Ohio (k)

Industrial Synthetics Corp., NJ (k)

Jackson Steel Products, Inc., NY (a, b,g)

Jarl Extrusions, Inc., NY (a)

Jessall Plastics Div., Electric Storage Battery Co., Conn (k)

Jessop Steel Co., Pa (g)

Jet Specialties Co., Inc., Calif (k)

Johns-Manville Corp., NY (k)

Johnson Metal Hose, Inc., Conn (b,f)

Johnson Plastic Corp., Ohio (k,m)

Johnson Rubber Co., Ohio (m)

Jones & Laughlin Steel Corp., Pa (g)

Jordan-Rogers Co., Calif (k)

Judson Rubber Works, Inc., Ill (m)

K S H Plastics, Inc., Mo (k)

Kaiser Aluminum & Chemical Sales, Inc., Ill (a)

Kaiser Steel Corp., Calif (g)

Kaufman Glass Co., Del (k,l)

Kenmore Machine Products, Inc., NY (b)

Kensico Tube Co., NY (b)

Kleiner Metal Specialties, Inc., NJ (g)

Knight, Maurice A. Co., Ohio (l)

Koehler Mfg. Co., Mass (g)

Kraloy Plastic Pipe Co., Inc., Calif (k)

Laclede Steel Co., Mo (g)

Lamtex Industries, Inc., NY (l)

Langsenkamp, F.H. Co., Ind (a,b)

Leach & Garner Co., Mass (b,f)

Lee Rubber & Tire Corp., Pa (m)

Lewin-Mathes Co., Mo (b)

Lewis & Saunders, NH (a,b,g)

Linderme Tube Co., Ohio (a,b)

Lock Joint Tube Co., Inc., Ind (g)

Lunn Laminates, Inc., NY (l)

Lus-Trus Corp., Mich (k)

Luzerne Rubber Co., NJ (k,l)

MacKenzie-Walton Co., RI (b)

Magline Inc., Mich (a,e)

Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (a,b,e,g)

Manufacturers Corp., Ohio (k)

Manufacturers & Fabricators, Inc., Ohio (f)

Markel, L. Frank & Sons, Pa (k,l,m)

Mechanical Rubber Products Co., NY (l)

Meier Brass & Aluminum Co., Mich (a,b)

Meier Screw Products & Mfg. Co., Mich (a,b,c,e,g)

Melco Wire Products, Calif (a)

Metal Forming Corp., Div. of Vanadium-Alloys Co., Ind (a,b,f,g)

Metal Goods Corp., Mo (a,b,f,g)

Midland Pipe & Supply Co., Ill (b,c,g)

Midvale-Heppenstall Co., Pa (g)

Minnesota Mining & Mfg. Co., Minn (k,l)

Missouri Boiler & Sheet Works, Mo (g)

Moore Drydock Co., Calif (g)

Morse, Fred W. Co., RI (a)

Moxness Products, Inc., Wis (m)

Mueller Brass Co., Mich
(b)—Ad p 404

Murray, A.B. Co., Inc., NJ (a,b,f,g)

Nalge Co., Inc., NY (k)

Narragansett Boiler Works, Inc., RI (g)

National Copper & Smelting Co., Ohio (b)

National Electric Div., H.K. Porter Co., Pa (g)

National Galvanizing Co., Pa (g)

National Gasket & Washer Mfg. Co., Inc., NY (k,l,m)

National Lead Co., NY (a,b,d)

National Lead Construction Co., Inc., Pa (d)

National Supply Co., Pa (g)

National Tube Div., U.S. Steel Corp., Pa (g)

National Tube Div., U.S. Steel Corp., Pa (k)

National Vulcanized Fibre Co., Del (k,l)

New England Tape Co., Div. of United-Carr Fastener Corp., Mass (k)

Newage Industries, Inc., Pa (k)

Nikoh Tube Co., Ill (g)

Noera Mfg. Co., Conn (b,g)

Nuclear Metals, Inc., Mass (a,b,c,e, f,g,h)

Ohio Seamless Tube Div., Copperweld Steel Co., Ohio (g)

Ohio Steel Foundry Co., Ohio (f)

Olds Alloys Co., Calif (b,d,f)

Olin Mathieson Chemical Corp., Metals Div., NY (g)

Oregon Metallurgical Corp., Ore (h)

Pabst Engineering Equipment Co., Inc., NJ (a,b,c,e,f,g,h,j)

Panelyte Div., St. Regis Paper Co., NY (k,l)

Parker Metal Goods Co., Mass (a,g)

Parker, Stearns & Co., Inc., NY (m)

Parker-Street Castings Co., Ohio (c)

Pencoyd Steel & Forge Corp., Pa (c,g)

Penn Brass & Copper Co., Pa (a,b)

Perfex Plastics, Inc., Ill (k)

Pfister Tubing Corp., NJ (a)

Philadelphia Bronze & Brass Corp., Pa (b)

Philrus Products Co., NJ (l)

Phoenix Steel Corp., NY (g)

Pittsburgh Steel Co., Pa (g)

Pittsburgh Tube Co., Pa (g)

Plastex Co., Ohio

Plastic Process Co., Inc., Calif (k)

Plymouth Cordage Co., Mass (k)

Polyform Plastics Corp., NY (k)

Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa (k)

Porter, William Co., Calif (l)

Precision Extrusions, Inc., Ill (a)

Precision Tube Co., Inc., Pa (a,b,f,g)

Pressed Steel Co., Pa (f)

Prince Rubber Co., Inc., NY (k,l)

Pyramid Moldings, Inc., Ill (g)

Pyramid Plastics, Inc., Ill (k,m)

Raybestos-Manhattan, Inc., NJ (m)

Rayclad Tubes, Inc., Calif (k,m)

Reading Tube Corp., NY (b)

Reflin Co., Calif (l)

Reinhold Engineering & Plastics Co., Calif (k)

Reliance Plastic & Chemical Corp., NJ (k)

Ren Plastics, Inc., Mich (l)

Replac Corp., Ohio (k,l,m)

Republic Steel Corp., Ohio (g)

Republic Steel Corp., Steel & Tubes Div., Ohio (f,g,h)

Republic Supply Co. of California (a,c,e,f,g,h)

Resistoflex Corp., NJ (l)

Revere Copper & Brass, Inc., NY (a,b,g)

Reynolds Aluminum Supply Co., Ga (a,g,b)

Reynolds Metals Co., Va (a)

Rigidized Metals Corp., NY (a,g)

Rockwell Engineering Co., Ill (a,b,c,g)

Rolled Alloys, Inc., Mich (f,g)

Rolock, Inc., Conn (f)

Rome Mfg. Div., Revere Copper & Brass, Inc., NY (g)

Rome Turney Radiator Co., NY (a,b,g)

Roth Steel Products Co., Ohio (g)

Rotometals, Calif (d)

Rowland Products, Inc., Conn (k)

Ryerson, Joseph T. & Son, Inc., Ill (a,g)

Sandusky Foundry & Machine Co., Ohio (b,f,g)

Sandvik Steel, Inc., NJ (g)

Sanford Plastics Corp., NY (k)

Saran Lined Pipe Co., Div. of Michigan Pipe Co., Mich (g)

Sawhill Tubular Products, Inc., Pa (f,g)

Schwab Plastics Corp., Mich (k,m)

Scovill Mfg. Co., Mill Products Div., Conn (b)

Service Steel Co., Mich (g)

Shamban, W.S. & Co., Ind (k)

Shaw-Kendall Engineering Co., Ohio (a,b,c,f,g)

Sheffield Plastics Co., Mass (k)

Sheldon, M. L. & Co., Inc., NY (f,g)

Shenango Furnace Co., Centrifugally Cast Products Div., Ohio (b,c,f)

Sierra Electric Corp., Calif (k)

Skyline Industries, Pa (k)

Small Tube Products, Inc., Pa (b)

Snyder, M.L. & Son, Inc., Pa (k)

Solar Steel Corp., Ohio (g)

South River Metal Products Co., Inc., NJ (a,e)

Southern Aluminum Finishing Co., Inc., Ga (a)

Southern Fabricating Co., Inc., Ala (g)

Southern Plastics Co., SC (k,m)

Southwestern Plastic Pipe Co., Tex (k)

Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)

Spiral-Glass Pipe Co., NJ (l,m)

Spuck Iron & Foundry Co., Mo (g)

Standard Metals Corp., Mass (b,f)

Standard Products Co., Mich (m)

Standard Tube Co., Mich (g)

Stauffer Chemical Co., Molded Products Div., Calif (k)

Stockwell Rubber Co., Inc., Pa (k,m)

Summerill Tubing Co. Div., Columbia Steel & Shafting Co., Pa (g)

Sunlite Plastics, Inc., Wis (k)

Superior Tube Co., Pa
(c,f,g,h)—Ad pp 424-425

Supplex Co., Div. of Amerace Corp., NJ (k,m)

Surprenant Mfg. Co., Mass (k)

Swepco Tube Corp., NJ (f)

Synthane Corp., Pa (l)

Tanner Engineering Co., Calif (l)

Taunton Div., Haveg Industries, Inc., Mass (m)

Taylor Fibre Co., Pa (l)

Technical Specialties Co., NY (m)

Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (g)

Texas Aluminum Co., Tex (a)

Thermoid Div., H. K. Porter Co., Pa (k,l,m)

Thompson Pipe & Steel Co., Colo (c,f, g)

Tickle, Arthur Engineering Works, Inc., NY (g)

Timken Roller Bearing Co., Ohio (g)

Titanium Metals Corp. of America, NY (h)

Tompkins Products, Mich (a)

Trent Tube Co., Pa (f,g,h)

Trenton Pipe Nipple Co., NJ (b,g)

Triangle Conduit & Cable Co., Inc., NJ (b,k)

Trim Alloys, Inc., Mass (a)

Tri-Point Plastics, Inc., NY (k)

Tube Distributors Co., Inc., NY (c,e,f, g,h)

Tube Methods, Inc., Pa (c,f,g)

Tube Reducing Corp., NJ (f,g,h)

Tuff Clad, Inc., Ohio (k)

Udylite Corp., Mich (k)

Uniform Tubes, Inc., Pa (a,b,f,g)

Union Steel Corp., NJ (g)

U.S. Flexible Tubing Co., Ill (g)

U.S. Gasket Plastics Div., Garlock Packing Co., NJ (k,l)

U.S. Steel Corp., Pa (g)

U.S. Steel Supply Div., U.S. Steel Corp., Ill (g)

U.S. Stoneware Co., Ohio (k)

U.S. Valve & Mfg. Co., Calif (g)

United Wire & Supply Corp., RI (a,b)

Universal Converting Corp., Mass (a)

Urrite Plastics Fabricators, Calif (k)

Vanadium-Alloys Steel Co., Pa (f,g)

Vanamatic Co., Ohio (g)

Van Huffel Tube Corp., Ohio (a,b,g)

Van Pelt Corp., Service Steel Div., Mich (f,g,h)

Viking Copper Tube Co., Ohio (b)

Viplax Products Corp., NJ (k)

Vogt Mfg. Corp., NY (k)

Vulcan Metal Products, Inc., Ala (a)

Vulcan Rail & Construction Co., NY (a,c,g)

Wall Tube & Metal Products Co., Tenn (b,f,g)

Wallingford Steel Co., Conn (g)

Wal-Mar Corp., Ill (a,b,c,e,g)

Waterman Industries, Inc., Calif (a,b)

Weiskittel, Harry C. Co., Inc., Md (c)

Welding Apparatus Co., Ill (a,f)

Wells, A.H. & Co., Inc., Conn (b)

Western Felt Works, Ill (l,m)

Western Textile Products Co., Mo (k,m)

Westinghouse Electric Corp., Micarta Div., SC
(l)—Ad pp 239-246

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Westlake Plastics Co., Pa (k,l,m)
Wheatland Tube Co., Pa (g)
Wheeling Steel Corp., Va (g)
White Metal Rolling & Stamping Corp., NY (a,e)
Whitehead Metal Products Co., Inc., NY (a,b,f,g)
William Brand-Rex Div., American Enka Corp., Mass (k)
Williams-Bowman Rubber Co., Ill (l, m)
Wolverine Tube, Div. of Calumet & Hecla, Inc., Mich (a,b,f,g,h)—Ad p 403
Woolf Aircraft Products, Inc., Mich (a,b,f,g)
World Plastics, NY (k)
Yardley Plastics Co., Ohio (k)
Youngstown Mfg., Inc., Ohio (a)
Youngstown Sheet and Tube Co., Ohio (g)
Youngstown Welding & Engineering Co., Ohio (a,f,h)

Tungsten

American Metal Climax, Inc., NY (aa)
American Nickel Alloy Mfg. Corp., NY (w,aa)
Associated Engineering & Mfg. Corp., NJ (o,aa,bb,cc,dd,ff)
Belmont Smelting & Refining Works, NY (aa)
Cleveland Tungsten, Inc., Ohio (aa, bb)
Electronic Parts Mfg. Co., Inc., NJ (bb,cc,ee,ff)
Elmet Div., North American Philips Co. Inc., Me (o,w,aa,bb,ff)
Esco Corp., Ore
Fansteel Metallurgical Corp., Ill (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff) — Ad pp 161-164
Firth Sterling Inc., Pa (q,aa,bb)
Fromson Orban Co., Inc., NY (ff)
General Electric Co., Lamp Metals & Components Dept., Ohio (o,q,w, aa,bb,cc,dd,ee,ff)
Gibson Electric Sales Corp., Pa (aa)
Hardy, Charles, Inc., NY (aa)
Harvey Aluminum, Calif (o,bb)
Hayden Wire Works, Inc., Mass (ff)
Industrial Tectronics, Inc., Mich
Kassel Export Co., Inc., NJ (v,bb, dd,ff)
Kennametal, Inc., Pa (o,bb)—Ad p 323
Kinkead Industries, Inc., Ill (o)
Linde Co. Div., Union Carbide Corp., NY
Metals & Residues, Inc., NJ (aa)
Molybdenum Corp. of America, Pa (o, w,z,aa,bb,cc,dd)
Nuclear Metals, Inc., Mass (w,bb, dd,ff)
Oregon Metallurgical Corp., Ore (w)
Plasmadyne Corp., Calif (aa)
Plasmatech Div., Valley Metallurgical Processing Co., Conn (aa)
Reduction & Refining Co., NJ (q,w,aa, bb,ff)
Schwarzkopf Development Corp., NY (n,aa,bb,cc,dd,ee,ff)
Shieldalloy Corp., NJ (aa)
Stauffer Chemical Co., NY (q)
Superior Carbon Products, Inc., Ohio
Sylvania Electric Products, Inc., Chemical & Metallurgical Div., Pa (w,aa,bb,ff)
Temescal Metallurgical Corp., Calif (w,z)—Ad p 167
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Universal-Cyclops Steel Corp., Pa (o, q,z,cc)
Vacuum Technology, Inc., Calif (cc,dd)
Wah Chang Corp., NY (n,aa,bb,cc,ff) Ad p 152
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc, dd,ee)

Upset Forgings

(see Forgings)

Ureas

Adhesive Products Corp., NY (x)
Alcylite Plastics & Chemical Corp., Calif (p,x,y)
Allied Chemical Corp., Plastics Div., NY (p,y)
American Cyanamid Co., Plastics & Resins Div., NY (p,u)
American Viscose Corp., Pa (y)
American-Marietta Co., Adhesive, Resin & Chemical Div., Wash (p)
Archer-Daniels-Midland Co., Minn (p)
Booty Resineers Div., American-Marietta Co., Ohio (p)
Borden Co., Borden Chemical Div., NY (p)
Catalin Corp. of America, NY (p,x)
Chemore Corp., NY (p,y)
Colton Chemical Co., Div. of Air Reduction Co., Inc., Ohio (u)
Dunnican Asso., NJ (y)
Dyna-Therm Chemical Corp., Calif (p)
Furane Plastics, Inc., Calif (x)
Gordon Chemicals, Inc., Del (y)
Grigoleit Co., Ill (p,s)
Kurz Kasch, Inc., Ohio (y)
Luminous Resins, Inc., Ill (y)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (bb,cc)
Monsanto Chemical Co., Plastics Div. Mass (p)
Muehlstein, H. & Co., Inc., NY (p,y)
Nopco Chemical Co., NJ (p)
Omni Products Corp., NY (p)
Reichhold Chemicals, Inc., NY (p,x)
Sierra Electric Corp., Calif (y)
Specialty Resins Co., Calif (p)
Sylvan Plastics, Inc., Pa (y)
Synco Resins, Inc., Conn (p)
Texas Glass Fiber Corp., Tex (y)

Urethane Elastomers

Acushnet Process Co., Mass (y)
Adhesive Products Corp., NY (x)
American Latex Products Co., Calif
American Rubber Products Corp., Ind (u,cc,dd)
B.B. Chemical Co., Bostik Dept., Mass (u)
Bond International, Inc., Mich (y,ee)
Brown Rubber Co., Inc., Ind (u)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chemical Coatings & Engineering Co., Inc., Pa (p,u,x,y)
Chicago-Allis Mfg. Corp., Ill (p)
Coast Pro-Seal & Mfg. Co., Calif (y)
Colonial Rubber Corp., Ohio (y,cc)—Ad p 416
Continental Rubber Works, Pa (bb,cc, dd,ee)
Dayton Rubber Co., Ohio (p,u,x,y,bb, cc,dd,ee)
Disogrin Industries, NY (bb,cc)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E. I. & Co., Inc., Del (v)
Dunlap Tire & Rubber Corp., NY (bb, cc,dd,ee)
Dyna-Therm Chemical Corp., Calif (p,x)
Faultless Rubber Co., Ohio (u)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (u)
Flexible Tubing Corp., Conn (ee)
Foam Products, Inc., Pa (u)
Foamade Industries, Mich (u,x,y,cc,dd)
General Electric Co., Plastics Dept., Ill (u)
General Plastics Mfg. Co., Wash (u,cc)
General Tire & Rubber Co., Chemical Div., Ohio (p)
Goodrich, B.F. Chemical Co., Ohio (p)—Ad pp 266-267
Hewitt-Robins, Inc., Conn (u,cc)
Hudson Cush-N-Foam Corp., NJ (u, bb,cc)
Isocyanate Products, Inc., Del (p,u)
Maco Industries, Inc., Ill (bb,cc,dd,ee)
Maloney, F.H. Co., Tex (x,y)
Marblette Corp., NY
Mobay Chemical Co., Pa (p,u,x,y)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,u,x,y)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (y)
Pelron Corp., Ill (p,u,x,y)
Plas-Kem Corp., Div. of Dyna-Therm Chemical Corp., Calif (x)
Prince Rubber & Plastics Co., Inc., NY (bb)
Products Research Co., Calif (y)
Reynolds Chemical Products Co., Mich (p,u,x)
Schwab Plastics Corp., Mich (u)
Scott Paper Co., Foam Div., Pa (u)
Sheller Mfg. Corp., Mich (u)
Sterling Alderfer Co., Ohio (u,dd)
Stockwell Rubber Co., Inc., Pa (u,cc)
Taunton Div., Haveg Industries, Inc., Mass (u)
Technical Specialties Co., NY (dd)
Thermoid Div., H. K. Porter Co., Pa (u)
Thiokol Chemical Corp., NJ (p,y)
Thombert, Inc., Iowa (bb,cc)
Toyad Corp., Pa (t,u)
Trostel, Albert Packing, Ltd., Wis (y)
United Shoe Machinery Corp., Mass (p,u)
U.S. Rubber Co., NY (p)
Vulcan Div., Reeves Bros., Inc., NY (p,y,cc)
Western Felt Works, Ill (y,cc,dd,ee)
Witco Chemical Co., Ill (p,u)
Wyandotte Chemicals Corp., Mich (p,u)

Urethane Foams

Adhesive Products Corp., NY (x)
American Latex Products Corp., Calif
American Rubber Products Corp., Ind (u,cc,dd)
Aries Laboratories, Inc., Conn (u)
Atlas Chemical Industries, Inc., Del (u)
Atlas Mineral Products Co., Pa (u)
B.B. Chemical Co., Bostik Dept., Mass (u)
Burkart, F. Mfg Co., Mo (u)
Carolina Industrial Plastics Div., Essex Wire Corp., NC (u)
Carwin Co., Conn (u)
Chemical Coatings & Engineering Co., Inc., Pa (p,u,x,y)
Columbus Coated Fabrics Corp., Ohio (u)
Crest Chemical Industries Corp., NY (u)
CrystalX Corp., Pa (u)
Dayton Rubber Co., Ohio (p,u,x,y,bb, cc,dd,ee)
Disogrin Industries, NY (bb,cc)
Dow Chemical Co., Plastic Div., Mich (u)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (u,y)
du Pont de Nemours, E. I. & Co., Inc., Del (u)
Durez Plastics Div., Hooker Chemical Corp., NY (u)
Dyna-Therm Chemical Corp., Calif (p)
Earl Paint Corp., NY
Electro Chemical Engineering & Mfg. Co., Pa (u,cc)
Englander Co., Inc., Industrial Products Div., Md (u)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (u)
Foam Products, Inc., Pa (u)
Foamade Industries, Mich (u,x,y,cc,dd)
Foss Mfg. Co., Id (u)
Freeman Chemical Corp., Wis (p)
Fry Plastics International, Calif (u)
Furane Plastics, Inc., Calif (u)
General Plastics Mfg. Co., Wash (u, cc)
General Tire & Rubber Co., Ind (u)
General Tire & Rubber Co., Chemical Div., Ohio (p)
Goodrich, B.F. Chemical Co., Sponge Products Div., Conn (u)
Hadley Bros.-Uhl Co., Mo (u)
Hewitt-Robins, Inc., Conn (u,cc)
Hexcel Products, Inc., Calif
Industrial Paint Div., Glidden Co., Ohio (p,u)
Interchemical Corp., Finishes Div., NJ (u)
Isocyanate Products, Inc., Del (p,u)
Luminous Resins, Inc., Ill (y)
Maloney, F.H. Co., Tex (y)
Marion Div., General Tire & Rubber Co., Ind (u)
Mobay Chemical Co., Pa (p,u,x,y)
Nesbitt Industries, Inc., Ill (u)
Nopco Chemical Co., NJ (p,u,x,y,cc)
Paeco Rubber Co., Inc., Ohio (y,dd, ee)
Pelron Corp., Ill (p,x,y)
Pittsburgh Corning Corp., Pa (u)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Polytron Corp., Calif (p,u)
Products Research Co., Calif (y)
Quelcor, Inc., Pa (u)
Reichhold Chemicals, Inc., NY (u)
Richardson Co., NY (bb,cc,ee)
Russell Reinforced Plastics Corp., NY (u)
Schenectady Varnish Co., Inc., NY (p)
Schwab Plastic Corp., Mich (u)
Scott Paper Co., Foam Div., Pa (u)
Sheller Mfg. Corp., Mich (u)
Southern Plastics Co., NC (bb,cc,dd, ee)
Sterling Alderfer Co., Ohio (u,dd)
Strick Plastics Co., Pa (u)
Thiokol Chemical Corp., NJ (p,u,x,y)
Toyad Corp., Pa (u)
United Shoe Machinery Corp., Mass (t,u)
William Brand-Rex Div., American Enka Corp., Mass (ee)
Witco Chemical Co., Ill (p,u)
Woodall Industries, Inc., Mich
Wyandotte Chemicals Corp., Mich (p,u)

Vacuum Formed Parts

(see Moldings, Sheet)

Vacuum Metallizing

(see Metallized Coatings)

Vanadium

American Metal Climax, Inc., NY (o)
American Nickel Alloy Mfg. Corp., NY (w)
Belmont Smelting & Refining Works, Inc., NY (aa)
Bishop, J. & Co. Platinum Works, Pa (ee)
Chicago Development Corp., Md (aa)
Hardy, Charles, Inc., NY (aa)
Linde Co., Div. of Union Carbide Corp., NY
Magnesium Elektron, Inc., NY (w,aa)
National-Standard Co., Mich (ff)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Nuclear Metals, Inc., Mass (w,bb,ee)
Oregon Metallurgical Corp., Ore (v,w)
Shieldalloy Corp., NY (aa)
Texas Instruments, Inc., Metals & Controls Div., Mass (v)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (w,z,aa, bb,dd,ff)
Vanadium Corp. of America, NY (o,v,z,bb,cc,dd,ee,ff)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd, ee)
Wolverine Tube Div., Calumet & Hecla, Inc., Mich (ee)

Varnishes

(see Organic Coatings)

Vinyls

(Polyvinyl chloride and copolymers)

Adhesive Products Corp., NY (p,x,y)
Air Reduction Chemical and Carbide Co., Div. of Air Reduction Co., Inc., NY (p)
Albany Novelty Mfg. Co., Mass (cc)
Albert Pipe Supply Co., Inc., NY (ee)
Alpha Plastics, Inc., NJ (bb,ee)
Alpha Wire Corp., NY (cc,ee)
Amercoat Corp., Calif (cc,ee)
American Hard Rubber Co., Div. of Amerace Corp., NJ (y,bb,cc,dd,ee)
American Products Mfg. Co., La (p,t,cc)
Anchor Plastics Co., Inc., NY (bb,dd,ee)
Argo Plastic Products Co., Ohio (bb,cc,dd,ee)
Atlas Mineral Products Co., Pa (cc,ee)
Auburn Plastics, Inc., NY (y,bb,cc,dd,ee)
Automotive Rubber Co., Inc., Mich (u,y,cc,dd)
Avery Label Co., Calif (u)
Blacher, B., NY (t)
Blossom Mfg. Co., NY (t,cc,dd)
Bolta Products Div., General Tire & Rubber Co., Mass (s,t,bb,cc,ee)
Borden Chemical Co., Div. of Borden Co., NY (p,ee)
Bradley & Vrooman Co., Ill
Byers, A.M. Co., Pa (ee)
Cadillac Plastic & Chemical Co., Mich (t,cc,ee)
Carolina Industrial Plastics Div., Essex Wire Corp., NC (u,ee)
Carroll, J.B. Co., Ill (x,cc)
Chemical Products Corp., RI (u,y)—Ad p 352
Chemore Corp., NY (p,s,y)
Colonial Plastics Mfg. Co., Div. of Van Dorn Iron Works, Ohio (bb,cc,dd,ee)
Columbus Coated Fabrics Corp., Ohio (t)
Comco Plastics, Inc., NY (cc,dd,ee)
Commercial Plastics & Supply Corp., NY (cc,ee)
Conneaut Rubber and Plastics Co., Div. of U.S. Stoneware Co., Ohio (bb,cc,dd,ee)
Cordo Chemical Corp., Conn (t,u,x,y)
Crane Plastics, Inc., Ohio (bb,dd,ee)
Crescent Plastics, Inc., Ind (ee)
Crest Chemical Industries Corp., NY (u)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (cc,ee)
Dennis Chemical Co., Mo (u,x,y)
Dewey & Almy Chemical Div., W. R. Grace & Co., Mass (p)
Diamond Alkali Co., Ohio (p)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Douglas & Sturgess, Calif (p,x,y)
Dow Chemical Co., Plastics Div., Mich (p,y)—Ad pp 249-256
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
Dunlop Tire & Rubber Corp., NY (bb,cc,dd,ee)
Dura Plastics of New York, Inc., NY (x,bb,cc,dd,ee)
Elm Coated Fabrics Co., Inc., NY (t,cc)
Escambia Chemical Corp., NY (p)
Esco Corp., Ore (bb,cc,dd,ee)
Firestone Plastics Co., Pa (s,t)
Flexible Tubing Corp., Conn (ee)
Frank, J. P. Chemical & Plastic Corp., NY (p,cc)
Fry Plastics International, Calif (t,u,cc,dd,ee)
Galigher Co., Utah (bb,cc,dd,ee)
Geauga Industries Co., Ohio (p,bb,dd,ee)
General Tire & Rubber Co., Chemical Div., Ohio (p)
General Tire & Rubber Co., Textileather Div., Ohio (t)
Genesee Laboratory, Inc., NY (bb,dd,ee)
Gering Plastics Div., Studebaker-Packard Corp., NJ (y,bb,dd,ee)
Glass Laboratories, Inc., NY (dd)
Gomar Mfg. Co., Inc., NJ (t)
Goodrich, B.F. Co., Sponge Products Div., Conn (u)
Goodrich Chemical Co., Ohio (p,u,x,y)—Ad pp 266-267
Goodrich, B.F. Industrial Products Co., Ohio (t,bb,cc,dd,ee)
Goodyear Tire & Rubber Co., Ohio (p,x)
Great American Industries, Inc., Rubatex Div., Va (u)
Hall Mfg. Corp., NJ (dd,ee)
Hauger-Beegle Asso., Inc., Ill (t)
Heyden Newport Chemical Corp., American Plastics Corp. Div., NY (bb,ee)
Hydrawlik, NJ (bb,ee)
Industrial Plastics Corp., Ind (bb,dd,ee)
Insulation Mfrs. Corp., Ill (ee)
Interchemical Corp., Finishes Div., NJ (u)
K-S-H Plastics, Inc., Mo (bb,cc,dd,ee)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Kaykor Industries, Inc., Div. of Kaye-Tex Mfg. Corp., NJ (bb,cc,dd)
Knight, Maurice A. Co., Ohio (cc)
Kuss, R.L. & Co., Inc., Ohio (t,cc)
Lus-Trus Corp., Mich (bb,cc,dd,ee)
Mannesmann-Easton Plastic Products Co., Inc., Pa (bb,ee)
Masland Duraleather Co., Pa (t,cc)
Mayon Plastics, Minn (bb,ee)
Mono-Sol Corp., Ind (u)
Monsanto Chemical Co., Organic Chemicals Div., Mo (p)
Monsanto Chemical Co., Plastics Div., Mass (p,t,u,x,y,cc)—Ad pp 212-213
Morningstar-Paisley, Inc., NY (p)
Nalge Co., Inc., NY (ee)
National Gasket & Washer Mfg. Co., Inc., NY (cc,dd,ee)
National Tube Div., U.S. Steel Corp., Pa (ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,u,x,y)
New England Tape Co., Div. of United-Carr Fastener Corp., Mass (bb,dd,ee)
Newage Industries, Inc., Pa (ee)
Nixon-Baldwin Chemicals, Inc., NJ (cc)
O'Sullivan Rubber Corp., Va (t)—Ad p 215
Pawling Rubber Corp., NY (bb,dd,ee)
Perfex Plastics, Inc., Ill (bb,dd,ee)
Plas Kem Corp., Div. of Dyna-Therm Chemical Corp., Calif (u,x,y)
Plast-Ad Mfg. Co., Ind (bb,cc,dd,ee)
Polo Plastics Co., Wis (t,u,cc)
Poly Resins, Calif (p,x)
Premier Thermo Plastics Co., Ky (u,y)
Prince Rubber & Plastics Co., Inc., NY (bb,cc,dd,ee)
Pyramid Plastics, Inc., Ill (bb,dd,ee)
Pyrosil, Inc., Ohio (cc)
Quelcor, Inc., Pa (u,x,y,cc)
Reichhold Chemicals, Inc., NY (p)
Reliance Plastic & Chemical Corp., NJ (bb,cc,dd,ee)
Republic Rubber Div., Lee Rubber and Tire Corp., Ohio (dd,ee)
Reynolds Chemical Products Co., Mich (u,x,y)
Reynolds Metals Co., Va (t,x,cc)
Ross & Roberts, Inc., Conn (t,cc)
Rubber Corp. of America, NY (p,t,x,y,cc)
Rubber & Plastics Compound Co., Inc., NY (cc)
Ryerson, Joseph T. & Son, Inc., Ill (cc,ee)
Schlegel Mfg. Co., NY (cc)
Scranton Plastic Laminating Corp., Pa (t,x,cc,dd)
Seiberling Rubber Co., Plastics Div., Ohio (t,u,cc)
Sheffield Plastics, Inc., Mass (ee)
Snyder Mfg. Co., Inc., Ohio (cc)
Southern Plastics Co., SC (bb,cc,dd,ee)
Sperry Rubber & Plastics Co., Ind (dd,ee)
Stockwell Rubber Co., Inc., Pa (bb,cc,ee)
Stokes Molded Products Div., Electric Storage Battery Co., NJ
Structural Products Div., National Starch & Chemical Corp., NY (p)
Sun Steel Co., Ill (t,x,cc,dd)
Sunlite Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., Ill (bb,cc,dd,ee)
Supplex Co., Div. of Amerace Corp., NJ (y,bb,dd,ee)
Taunton Div., Haveg Industries, Inc., Mass (ee)
Toyad Corp., Pa (u)
Tuff Clad, Inc., Ohio (x,cc)
Union Carbide Plastics Co., Div. of Union Carbide Corp., NY (p,t,u,y,cc)
U.S. Rubber Co., NY (p,y)
U.S. Stoneware Co., Ohio (bb,cc,dd,ee)
Varflex Corp., NY (ee)
Watson-Standard Co., Pa (u,y)
Western Textile Products Co., Mo (ee)
Whirlclad Div., Polymer Corp., Pa (p)
Whitehead Metal Products Co., Inc., NY (bb,cc,dd,ee)
William Brand-Rex Div., American Enka Corp., Mass (bb,dd,ee)

Vinyls

(Saran; polyvinyl alcohol, butyral and formal)

Air Reduction Chemical & Carbide Co., Div. of Air Reduction Co., Inc., NY (p,s)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,cc,dd,ee)
Automotive Rubber Co., Inc., Mich (cc,dd)
Avery Label Co., Calif (u)
Bolta Products Div., General Tire & Rubber Co., Mass (t)
Borden Chemical Co., Div. of Borden Co., NY (p)
Cadillac Plastic & Chemical Co., Mich (t)
De Soto Chemical Coatings, Inc., Ill (p)
Dewey & Almy Chemical Div., W. R. Grace & Co., Mass (p)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Dow Chemical Co., Plastics Div., Mich (p,t,y,bb,cc,dd,ee)
du Pont de Nemours, E. I. & Co., Inc., Del (p,t,x)
Franklin Glue Co., Ohio (p)
Fry Plastics International, Calif (t,u,cc,dd,ee)
Heyden Newport Chemical Corp., American Plastics Corp. Div., NY (bb,ee)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Kuss, R. L. & Co., Inc., Ohio (s,t,cc)
Lus-Trus Corp., Mich (bb,dd,ee)
Mono-Sol Corp., Ind (t)
Monsanto Chemical Co., Plastics Div., Mass (t)
Plas Kem Corp., Div. of Dyna-Therm Corp., Calif (u,x,y)
Plast-Ad Mfg. Co., Ind (cc)
Prince Rubber & Plastics Co., Inc., NY (ee)
Pyramid Plastics, Inc., Ill (bb,cc,dd,ee)
Resistoflex Corp., NJ (cc,ee)
Reynolds Metals Co., Va (t,x,cc)
Saran Lined Pipe Co., Div. of Michigan Pipe Co., Mich (bb,cc,ee)
Schlegel Mfg. Co., NY (cc)
Shawinigan Resins Corp., Mass (p,y)
Sierracin Corp., Calif (cc)
Snyder Mfg. Co., Inc., Ohio (cc)
Stockwell Rubber Co., Inc., Pa (bb,cc,ee)
Stokes Molded Products Div., Electric Storage Battery Co., NJ
Structural Products Div., National Starch & Chemical Corp., NY (p)
Union Carbide Plastics Co., Div. of Union Carbide Corp., NY (p)
Whitehead Metal Products Co., Inc., NY (ee)

Vulcanized Fibre

Ace Plastic Co., NY (bb,cc)
Baer, N.S. Co., NJ (bb,cc,dd,ee)
Cleveland Container Co., Ohio (ee)
Colonial Kolonite Co., Ill (bb,cc,ee)
Comco Plastics, Inc., NY (bb,cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Coyne & Paddock, Inc., NY (cc)
Curbell, Inc., NY (bb,cc,ee)
Electrofilm, Inc., Calif (t)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Insulation Mfrs. Corp., Ill (bb,cc,dd,ee)
Iten Fibre Co., Ohio (s,bb,cc,dd,ee)
Laminated Plastex Corp., Ohio (z,cc)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
National Vulcanized Fibre Co., Del (bb,cc,dd,ee)
Penn Fibre & Specialty Co., Inc., Pa (bb,cc,dd,ee)
Philrus Products Co., NJ (bb,cc,dd,ee)
Spaulding Fibre Co., Inc., NY (bb,cc,dd,ee)—Ad p 277
Staver Co., Inc., NY (cc,dd)
Taylor Fibre Co., Pa (bb,cc,dd)—Ad p 265
Thombert, Inc., Iowa (cc,dd)
Westlake Plastics Co., Pa (bb,cc,dd,ee)
Wilmington Fibre Specialty Co., Del (bb,cc,dd,ee)
Wisconsin Gasket & Mfg. Co., Wis (cc)

Welding Rods and Electrodes

(see Filler Metals)

Weldments

Abalon Precision Mfg. Corp., NY (a,b,c,g)
Acme Precision Products, Inc., Ohio (a,f,g)
Acorn Sheet Metal Mfg. Co., Inc., Ill (a,g)
Adams, I.G. Metalware Co., Mo (g)
Albert Pipe Supply Co., Inc., NY (g)
Alco Products, Inc., NY (a,b,f,g)
Allis-Chalmers Mfg. Co., Wis. (a,f,g)
Alloy Products Corp., Wis (a,f,g,h)—Ad p 434
Almco Steel Products Corp., Ind (a,b,c,g)
Aluminum Co. of America, Pa (a)
Amalgamated Steel Corp., Ohio (g)
American Brake Shoe Co., NY (b)
American Car & Foundry Div., ACF Industries, Inc., NY (a,e,g)
American Cast Iron Pipe Co., Ala (g)
American Machine & Foundry Co., Cleveland Welding Div., Ohio (a,c,f,g,h)
American Metal Products Co., Mich (a,g)
American Pipe & Construction Co., Ore (a,g)
American Sheet Metal Works, Inc., Conn (a,g)
American Welding and Mfg. Co., Ohio (a,f,g,h)
Ampco Metal, Inc., Wis (b)
Anderson, O.L. Co., Inc., Mich (a,b,c,d,g)
Armor Metal Products Co., Ohio (a,g)
Atlas Steel Construction Co., NY (a,b,c,g)
Automotive Rubber Co., Inc., Mich (a,c,e,g)
Baldwin-Lima-Hamilton Corp., Pa (a,g)
Barclay Mfg. Co., Ind (c)
Beatty Machine & Mfg. Co., Ind (g)
Behringer Metal Works, Inc., NJ (a,g)
Beloit Iron Works, Wis (c,g)
Bergen Point Iron Works, NY (a,b,c,f,g,h)
Bethlehem Steel Co., Pa (g)
Biersach & Niedermeyer Co., Wis (a,b,c,g)
Blaw-Knox Co., Pa (a,g)
Blickman, S. Inc., NJ (a,b,c,f,h)
Brinkerhoff Brass & Bronze Works, Inc., NY (a,b,c,f,g)
Brooks & Perkins, Inc., Mich (a,e,g,h)—Ad p 420
Burkhardt Steel Co., Colo (c,g)
Butler Mfg. Co., Mo (a,g)
Caldwell, W.E. Co., Ky (a,g)
Central Fabricators, Inc., Ohio (a,b,c,f,g,h)
Clarksville Foundry & Machine Works, Tenn (a,c)
Cleveland Steel Specialty Co., Ohio (g)
Combined Industries Co., NY (a,b,c,e,f)
Combustion Engineering, Inc., Ill (a,b,g)
Commercial Shearing & Stamping Co., Ohio (g)
Continental Copper & Steel Industries Inc., NY (a,b,c,e,f,g,h)
Cornell and Underhill, Inc., NJ (a,g)
Darby Corp., Kan (a,f,g)
Dare Products, Inc., Mich (g)
Day Co., Minn (a,g)
Dixie Bronze Co., Ala (b)
Dolin Metal Products, Inc., NY (g)
Dow Chemical Co., Mich (e)
Downington Iron Works, Pa (c,g)
Dravo Corp., Pa (a,g)
Dresser Mfg. Div., Dresser Industries, Inc., Pa (g)
Ellicott-Brandt, Inc., Md (a,b,e,f,g)
Emerson-Sack-Warner Corp., Mass (a,f,g)
Enterprise Wheel & Car Corp., Va (a,g)
Esco Corp., Ore (g)
Evans, George Corp., Ill (g)
Everard Tap & Die Corp., NY (a,g)
Falk Corp., Wis (g)
Falstrom Co., NJ (a,b,c,d,e,f,g,h,J)
Farwell Metal Fabricating, Minn (a,c,e,f,g)
Federal Machine and Welder Co., Ohio (g)
Fitzgibbons Boiler Co., Inc., NY (c)
Foster Wheeler Corp., NY (a,f,g)
Gary Steel Products Corp., Va (a,g)
General Alloys Co., Mass (a,b,f)
General American Transportation Corp., Ill (a,c,g)
General American Transportation Corp., Plate & Welding Div., Ill. (a,c,g)
General Cable Corp., NY (g)
Glasby J.P. Mfg. Co., Inc., NJ (a,c,e,f,g)
Goslin Birmingham Mfg. Co., Inc., Ala (b,f,g)
Graver Tank & Mfg. Co. Div., Union Tank Car Co., Ind (a,f,g)
Greene, G.G. Corp., Pa (g)
Hardy, Mfg. Corp., Ind (g)
Hazledine, E.T. Co., Ind (g)
Hibben & Co., Ill (a,g)
Hicks Corp., Mass (a,b,g)
Hobbs, Clinton E. Co., Mass (c,g)
Houston Blow Pipe & Sheet Metal Works, Tex (a,b,g)
Huntington Alloy Products Div., International Nickel Co., Inc., W.Va (f)
Ideal Can Co., Mass (a,c,g)
Indus Corp., Ind (a,g)
Industrial Equipment Co., Ohio (a,g)
Industrial Pipe & Supply Co., Ill (g)
Industrial Precision Products, Ill (a,c)
Ingalls Iron Works Co., Ala (c,g)
Ingersoll Products Div., Borg-Warner Corp., Ill (g)
Inland Mfg. Co., Neb (g)
Irvington Form & Tank Corp., NY (a,b,g)
Irwin-Sensenich Corp., Pa (a,g)
Jervis Corp., Mich (a,g)
K-D Mfg. Co., Tex (c,g)
Kaiser Steel Corp., Calif (g)
Kelsey-Hayes Co., Mich (g)
Kewaunee Engineering Corp., Wis (g)
King, Alfred B. Co., Conn (a,b,c,d,f,g)
King Fifth Wheel Co., Pa (g)
Kirk & Blum Mfg. Co., Ohio (g)
Koven, L.O. & Bro., Inc., NJ (a,g)
Krueger Fabricating Co., Inc., Wis (a,b,c,e,g)
LFM Mfg. Co., Inc., Sub. of Rockwell Mfg. Co., Kan (g)
Langsenkamp, F.H. Co., Ind (a,b)
Larkin Specialty Mfg. Co., Calif (a,b,g)
Lawrence, L. Co., Inc., NJ (a,b,c,e,f,g,h,J)
Leader Iron Works, Inc., Ill (a,b,c,f,g)
Levinson Steel Co., Pa (g)
Lincoln Steel Corp., Neb (g)
Littleford Bros. Inc., Ohio (a,c,f,g)
Lockport Steel Fabricators, Inc., Ill (a,f,g)
Loeffler, J.M. Machine Co., Pa (a,b,c)
Lukens Steel Co., Pa (a,b,e,f,g,h)
Machine Products Corp., Ohio (a,b,c,f,g)
Magline, Inc., Mich (a,e)
Mahon, R.C. Co., Mich (a,g)
Manganese Steel Forge Co., Pa (g)
Manufacturers & Fabricators, Inc., Ohio (f,g)
Manufacturers Service, Inc., Ohio (a,b,g)
Mayville Metal Products Co., Wis (g)
McDowell-Wellman Cos., Ohio (g)
McGregor-Michigan Corp., Mich (c,f,g)
McLanahan & Stone Corp., Pa (g)
McNally Pittsburg Mfg. Co., Kan (a,c,g)
Midvale-Heppenstall Co., Pa (g)
Midwest Piping Co., Inc., Mich (g)
Mid-West Wire Products Co., Inc., Mich
Missouri Boiler & Sheet Works, Mo (g)
Moore Dry Dock Co., Calif (g)
Morrisville Foundry Co., Inc., Vt (g)
Morse, Fred W. Co., RI (a,b,c,g,J)
Murray, A.B. Co., Inc., NJ (a,b,f,g)
Murray Tube Works Inc., NJ (g)
Narragansett Boiler Works, Inc., RI (g)
National Lead Construction Co., Inc., Pa (d)
National Metal Products Co., Pa (a,c,g)
National Screw & Mfg. Co., Ohio (g)
National Steel & Shipbuilding Corp., Calif (a,g)
National Tank Co., Okla (a,g)
Nigg Engineering Corp., Calif (a,c,g)
Olean Electro Plating Co., NY (g)
Pabst Engineering Equipment Co., Inc., NJ (a,c,f,g)
Parish Pressed Steel Div., Dana Corp., Pa (a,g)
Patterson Foundry & Machine Co., Ohio (a,g)
Pennsylvania Engineering Corp., Pa (g)
Penrod, Floyd & Sons Tool & Engineering Corp., Ind (g)
Pfaudler Co., NY (a,f,g)
Philadelphia Bronze & Brass Corp., Pa (h)
Phoenix Steel Corp., NY (g)
Portland Co., Me (a,f,g)
Posey Iron Works, Inc., Pa (g)
Pressed Steel Tank Co., Wis (a,f,g)
Progressive Service Co., Mo (g)
Pusey & Jones Corp., Del (a,b,c,e,f,g)
Queen Products Co., Inc., Ky (a,g)
Rankin Forge Co., Pa (c,g)
Republic Steel Corp., Ohio (g)
Reynolds Metals Co., Va (a)
Rockwell Engineering Co., Ill (a,b,c,g)
Rockwell-Standard Corp., Stamping Div., NY (a,b,f,g)
Rolock, Inc., Conn (f,g)
Rose Iron Works, Ohio (a,b,c,f,g,h)
Sandy Hill Iron & Brass Works, NY (b,g)
Scaife Co., Pa (c,f,g)
Seattle Boiler Works, Inc., Wash (a,f,g)
Shank Metal Products Co., NY (a,g)
Sharpsville Steel Fabricators, Inc., Pa (a,b,c,f,g)
Sherman & Reilly, Inc., Tenn (a,e,f,g)
Shriver, T. & Co., Inc., NJ (a,g)
Sinclair Co., Mass (b,c,g)
Sioux City Foundry & Boiler Co., Iowa (g)
Smith, A.O. Corp., Wis (a,g)
South River Metal Products Co., Inc., NJ (a,e,g)
Southern Car & Mfg. Co., Inc., Ala (a,g)
Southwestern Porcelain Steel Corp., Okla (g)
Spincraft, Inc., Wis (a,b,c,d,e,f,g,h,J)
Spring City Foundry Co., Pa (c)
Spuck Iron & Foundry Co., Mo (g)
Stacey Mfg. Co., Ohio (a,g)
Stainless Metals, Inc., NY (c,f,h)
Stalker Corp., Mich (f,g,h)
Standard Steel Sections, Inc., NY (a,c,g)
Stanwood Corp., Ill (g)
Star Heel Plate Co., Inc., NJ (g)
Steel, R. & Sons, Inc., NY (g)
Steel Fabricators Co., Ohio (a,c,e,f,g,h)
Stover Co., Ill (d,f,g)
Struthers Wells Corp., NY (a,f,g,h)
Sylvania Electric Products, Inc., Parts Div., Pa (b,c,f,g)
Texas Foundries, Inc., Tex (g)
Thompson Pipe & Steel Co., Colo (a,b,c,d,e,g,h)
Thys Co., Calif (g)
Tickle Arthur Engineering Works, Inc., NY (g)
Toledo Stamping & Mfg. Co., Ohio (g)
Torngren, C.W. Co., Inc., Mass (a,b,c,f,g,h)
Trane Co., Wis (g)
Trojan Steel Co., W.Va (a,b,f,g)
Union Iron Works, Wash (g)
Union Tank Car Co., Ill (a,f,g)
United Shoe Machinery Corp., Mass (a,b,c,e,f,g)
U.S. Valve & Mfg. Co., Calif (g)
Variety Stamping Corp., Ohio (c,g)
Victor Steel Products Corp., NY (g)
Vulcan Mfg., Ohio (a,b,c,e,f,g,h)
Wall Colmonoy Corp., Mich (b,f,g)
Wal-Mar Corp., Ill (a,c,e,g)
Ward, H.H. Co., Pa (a,b,c,f,g,J)
Warren Brothers Roads Co., Mass (a,c,d,e,f,g,J)
Waterman Industries, Inc., Calif (a,g)
Werner, R.D. Co., Inc., NY
West Point Foundry & Machine Co., Ga (c)
Western Foundry & Machine Works, Inc., Kan (g)
Wheeler, C.H. Mfg. Co., Wheelerweld Div., Pa (b,c,f,g)
Whyte, Oliver Co., Inc., NY (a,c,g)
Wilder Mfg. Co., Inc., Calif (c,g)
Willamette Iron and Steel Co., Ore (f,g)
Wisconsin Centrifugal Foundry, Inc., Wis (b)
Woolf Aircraft Products, Inc., Mich (a,c,g)
Wyatt Metal & Boiler Works, Inc., Tex (a,b,c,e,f,g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)
Youngstown Welding & Engineering Co., Ohio (a,f,h)

Wire

Abalon Precision Mfg. Corp., NY (a,b,c,g)
Ace Wire Spring & Form Co., Inc., Pa (g)
Acme Stamping & Wire Forming Co., Pa (a,b,g)
Acme Steel Products Div., Acme Steel Co., Ill (g)
Alabama Wire Co., Inc., Ala (a)
Allegheny Ludlum Steel Corp., Pa (g)
All-State Welding Alloys Co., Inc., NY (a)
Almco Steel Products Corp., Ind (g)
Alofs Mfg. Co., Mich (a,g)
Alpha Wire Corp., NY (b)
Aluminum Co. of America, Pa (a)
American Chain & Cable Co., Pa (g)
American Electric Cable Co., Mass (b)
American Nickel Alloy Mfg. Corp., NY (f)
American Reed Co., Inc., Mass (c)
American Silver Co., NY (b,f,g,h)
American Smelting & Refining Co., NY
American Steel and Wire Div., U. S. Steel Corp., Ohio (b,g)

Ancher Drawn Steel Co., Div. of Vanadium-Alloys Steel Co., Pa (g)
Appalachian Steel Corp., NJ (g)
Arcos Corp., Pa (a,b,e,f,h)
Armco Steel Corp., Ohio (g)
Associated Spring Corp., Wallace Barnes Steel Div. Conn (g)
Athenia Steel Div., National-Standard Co., NJ (g)
Atlantic Bag Co., NY (g)
Atlantic Steel Co., Ga (g)
Baker Platinum Div., Engelhard Industries, Inc., NJ (a,b,f,g,h)
Belmont Smelting & Refining Works, Inc., NY (d,j)
Beryllium Corp., Pa (b)
Bethlehem Steel Co., Pa (g)
Bishop, J. & Co. Platinum Works, Pa
(f)—Ad p 394
Bridgeport Brass Co., Conn (a,b,f)
Bristol Brass Corp., Conn (b)
Cambridge Wire Cloth Co., Md (a,b, c,e,f,g,h)
Carol Cable Co., Div. of Crescent Co., Inc., RI (b)
Carpenter Steel Co., Pa (g)
Carpenter Steel Co., Webb Wire Div., NJ (g)
Central Steel & Wire Co., Ill (a,b,g)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (a,b, f,g)
Chicago Development Corp., Md (h)
Clendenin Bros., Inc., Md (a,b)
Colonial Alloys Co., Pa (a)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (g)
Colorado Fuel & Iron Corp., Colo (g)
Colorado Fuel & Iron Corp., Pacific Coast Div., Calif (g)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (b,g)
Comerford Mfg. Co., Inc., Conn (a,b, c,e,f,g,h,j)
Continental Steel Corp., Ind (g)
Copper and Brass Sales, Inc., Mich (a,b,e)
Crown Metal Co., Wis (d)
Crucible Steel Co. of America, Pa (g,h)
Dare Products, Inc., Mich (b,g)
Detroit Steel Corp., Portsmouth Div., Mich (g)
Division Lead Co., Ill (d)
Driver, Wilbur B. Co., NJ (b,f)
Driver-Harris Co., NJ (f)
Dudek & Bock Spring Mfg. Co., Ill (a,b,g)
Eaton Mfg. Co., Reliance Div., Ohio (a,b,e,g)
Edgcomb Steel & Aluminum Corp., NJ (a,g)
Electric Auto-Lite Co., Ohio (a,b)
Electronic Parts Mfg. Co., NJ (b,f)
Elgin National Watch Co., Ill (f)
Empire Metal Co., NY (d)
Erskine Precision Wire Corp., Pa (b, f,g)
Esco Corp., Ore (g)
Essex Industrial Products Div., Essex Wire Corp., Ind (a,b)
Essex Wire Corp., Magnet Wire Div., Ind (a,b)
Fort Wayne Metals, Inc., Ind (f,g)
Frasse, Peter A. & Co., Inc., NY (a,g)
Fromson Orban Co., Inc., NY (a)
General Alloys Co., Mass (a,b,f,g)
General Cable Corp., NY (a,b)
General Chain & Mfg. Corp., Ohio (g)
General Findings & Supply Co., Industrial Div., Mass (a,b,c,f,g)
Greene, G.G. Corp., Pa (g)
Hawkridge Bros. Co., Mass (a,h)
Hayden Wire Works, Inc., Mass (a, b,c,d,f,g,j)
Haynes Stellite Co., Div. of Union Carbide Corp., NY (f)
Hazledine, E.T. Co., Ind (g)
Hi-Grade Alloy Corp., Ill (d)
Hoskins Mfg. Co., Mich
(f,h)—Ad p 148
Hudson Wire Co., NY (a,b,j)
Huntington Alloy Products Div., International Nickel Co., Inc., W.Va (f)
Indiana Steel & Wire Co., Inc., Ind (g)
Indium Corp. of America, NY (d)
Jarco Metal Products, NY (g)
Jelliff, C.O. Mfg. Corp., Conn (f)
Johnson Steel and Wire Co., Inc., Mass (g)
Jones & Laughlin Steel Corp., Pa (g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kanthal Corp., Conn (c,f)
Kassel Export Co., Inc., NJ (a,b,c,g)
Kelsey-Hayes Co., Metals Div., NY (f)
Keystone Steel & Wire Co., Ill (g)
Laclede Steel Co., Mo (g)
Langsenkamp, F.H. Co., Ind (b)
La Salle Steel Co., Mo (g)
Leach & Garner Co., Mass (b,f)
Lincoln Steel Corp., Neb (g)
Little Falls Alloys, Inc., NJ
(a,b,h)—Ad p 426
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (a,b,e,g)
Manganese Steel Forge Co., Pa (g)
Matthiessen & Hegeler Zinc Co., Ill (j)
Meier Brass & Aluminum Co., Mich (a,g)
Melco Wire Products, Calif (a)
Metal Goods Corp., Mo (a,b,f)
Metallizing Co. of Los Angeles, Inc., Calif (a,b,c,d,f,g,j)
Mid-States Steel & Wire Co., Ind (g)
Mid-West Wire Products Co., Inc., Mich (g)
National Electric Div., H.K. Porter Co., Pa (a)
National Lead Co., NY (d,h)
National Lock Washer Co., NJ (g)
National-Standard Co., Mich (a,b,c,f, g,h,j)
Nesor Alloy Products Co., NJ (a,b,c, d,f,g,j)
New England Electrical Works, Inc., NH (b)
Nichols Wire & Aluminum Co., Iowa (a)
Northwestern Steel & Wire Co., Ill (g)
Okonite Co., Sub. of Kennecott Copper Corp., NJ (b)
Olin Mathieson Chemical Corp., Metals Div., NY (a)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa
(g)—Ad p 92
Peerless Wire Goods Co., Inc., Ind (g)
Philadelphia Steel & Wire Corp., Pa (g)
Pittsburgh Steel Co., Pa (g)
Reactive Metals, Inc., Ohio (h)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass Inc., NY (b)
Reynolds Aluminum Supply Co., Ga (a)
Reynolds Metals Co., Va (a)
Riverside-Alloy Metal Div., H. K. Porter Co., Inc., NJ (b,f,g)
Roebling's John A. Sons Div., Colorado Fuel & Iron Corp., NJ (a,b,g)
Rolled Alloys, Inc., Mich (f)
Rolock, Inc., Conn (f)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
Sandvik Steel, Inc., NJ (g)
Scovill Mfg. Co., Mill Products Div., Conn (b)
Seneca Wire & Mfg. Co., Ohio (g)
Sherman & Reilly, Inc., Tenn (g)
Simonsen Metal Products Co., Ill (a)
South River Metal Products Co., Inc., NJ (a)
Southern Metal Products Co., La (g)
Standard Metals Corp., Mass (b,f)
Star Heel Plate Co., Inc., NJ (a,b,g)
Stulz-Sickles Co., NJ (g)
Superior Mfg. Co., Pa (g)
Surprenant Mfg. Co., Mass (b)
Sylvania Electric Products, Inc., Parts Div., Pa (b,c,f,g)
Techalloy Co., Inc., Pa (f,g,h)
Tennessee Coal and Iron Div., U. S Steel Corp., Ala (b,g)
Titan Metal Mfg. Co. Div., Cerro Corp., Pa (b)
Triangle Conduit & Cable Co., Inc., NJ (a,b)
U. S. Steel Corp., Pa (g)
United Wire & Supply Corp., RI (a, b)
Universal-Cyclops Steel Corp., Pa (f,g)
Uniworld Research Corp. of America, Ohio (c)
Utility Mfg. Co., Mass (a,b,g)
Vanadium-Alloys Steel Co., Pa (g)
Wall Colmonoy Corp., Mich (f,g)
Wal-Mar Corp., Ill (a,b,c,e,g)
Washburn Wire Corp., Phillipsdale Div., RI (g)
Washington Mfg. Co., Inc., Iowa (g)
Wesco Spring Co., Ill (g)
White Metal Rolling & Stamping Corp., NY (a,e)
Whitehead Metal Products Co., Inc., NY (a,b,f,g)
Whyte, Oliver Co., Inc., NY (a,g)
Wickwire Brothers, Inc., NY (g)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (b,c)
Wilson Steel & Wire Co., Ill (g)
Youngstown Sheet and Tube Co., Ohio (g)

Wire Cloth

(incl. parts)

Alabama Wire Co., Inc., Ala (a)
American Steel and Wire Div., U. S. Steel Corp., Ohio (g)
Arcos Corp., Pa (e,h)
Biersach & Niedermeyer Co., Wis (a, g)
Bishop, J. & Co. Platinum Works, Pa (g)
Buffalo Wire Works Co., Inc., NY (a,b,c,f,g)
Cambridge Wire Cloth Co., Md (a,b, c,d,f,g,h,j)
Central Steel & Wire Co., Ill (a,b, f,g)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (a,b,f)
Cleveland Wire Cloth & Mfg. Co., Ohio (a,b,c,f,g,h,j)
Cole-Roscoe Mfg. Co., Conn (b,f,g,h)
Colorado Fuel & Iron Corp., Pacific Coast Div., Calif (g)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (g)
Esco Corp., Ore (g)
General Alloys Co., Mass (f)
General Cable Corp., NY (a,b)
Gilbert & Bennett Mfg. Co., Conn (a,g)
Green Bay Foundry & Machine Works, Wis (b,f)
Hewitt-Robins Inc., Conn (g)
Jelliff, C.O. Mfg. Corp., Conn (a,b,c, f,g)
Johnston & Funk Titanium Corp., Ohio (g,h)
Kassel Export Co., Inc., NJ (a,b,f)
Kenmore Machine Products, Inc., NY (f)
Manganese Steel Forge Co., Pa (a,b,c, f)
Metal Goods Corp., Mo (a,b,f)
Michigan Wire Cloth Co., Mich (a, b,f,g)
Mid-States Steel & Wire Co., Ind (g)
National-Standard Co., Reynolds Div., Ill (a,b,c,f,g,h,j)
Newark Wire Cloth Co., NJ
(a,b,c,f,g,h)—Ad p 396
Pequot Wire Cloth Co., Div. of Hudson Wire Co., Conn (a,b,f,g)
Phoenix Mfg. Co., Ill (g)
Rolock, Inc., Conn (a,b,f,g)
Rotometals, Calif (a,f)
Schlegel Mfg. Co., NY (a,g)
Seymour Mfg. Co., Conn (b)
Sherman & Reilly, Inc., Tenn (g)
Sherwatt Equipment & Mfg. Co., Inc., NY (a,b,c,e,f,g,h,j)
Sinclair Co., Mass (b,g)
Star Wire Screen & Iron Works, Inc., Calif (a,b,c,f,g)
Taylor-Wharton Co., Div. of Harsco Corp., NJ (g)
Tennessee Coal and Iron Div., U. S. Steel Corp., Ala (g)
Tyler, W.S. Co., Ohio (a,b,c,f,g)
Unique Wire Weaving Co., Inc., NJ (a,b,c,e,f,g,h)
U. S. Steel Corp., Pa (g)
Uniworld Research Corp. of America, Ohio (c)
Vulcan Metal Products, Inc., Ala (a)
Wesbar Stamping Corp., Wis (c,g)
Whitehead Metal Products Co., Inc., NY (a,b,f)
Wickwire Bros., Inc., NY (a,b,g)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (b,c)
Wright, G.F. Steel & Wire Co., Mass (a,b,f,g)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Wire Forms and Parts

(except cloth)

Abalon Precision Mfg. Corp., NY (a,b,c,g)
Ace Wire Spring & Form Co., Inc., Pa (g)
Acme Stamping & Wire Forming Co., Pa (a,b,g)
All-Form Metal Products Co., Ohio (a,b,c,f,g)
Alox Mfg. Co., Mo (a,b,c,f,g)
Aluminum Co. of America, Pa (a)
American Mfg. Co., Tenn (a,g)
American Metal Products Co., Mich (a,g)
American Reed Co., Inc., Mass (c)
Anthes Div., Gleason Corp., Iowa (g)
Armco Steel Corp., Ohio (g)
Art Wire & Stamping Co., NJ (a,b,c,e,f,g,h,j)—Ad p 396
Associated Spring Corp., Wallace Barnes Steel Div., Conn (g)
Automotive Rubber Co., Inc., Mich (f,g)
Bethlehem Steel Co., Pa (g)
Bishop, J. & Co. Platinum Works, Pa
Blacher Bros., Inc., RI (b,g)
Blaco Mfg. Co., Ohio (g)
Buffalo Wire Works Co., NY (a,b,f,g)
Cambridge Wire Cloth Co., Md (a,b,f,g)
Cartwright, R. Tube Products Co., Mich (b)
Clendenin Bros. Inc., Md (a,b,g)
Cleveland Metal Products Co., Ohio (a,b,f,g)
Colorado Fuel & Iron Corp., Colo (g)
Colorado Fuel & Iron Corp., Pacific Coast Div., Calif (g)
Columbus Dental Mfg. Co., Ohio (g)
Comerford Mfg. Co., Inc., Conn (a,b,c,e,f,g)
Dare Products, Inc., Mich (g)
Dudek & Bock Spring Mfg Co., Ill (a,b,g)
Eastern Tool & Mfg. Co., NJ (a,b,g)
Electronic Parts Mfg. Co., Inc., NJ (b,f)
Elgin National Watch Co., Ill (f)
Empire Spring Co., Ohio (g)
Farwell Metal Fabricating, Minn (a,b,c,e,f,g)
Figley Die & Stamping Co., Ohio (g)
General Alloys Co., Mass (a,b,f)
General Cable Corp., NY (a)
General Chain & Mfg. Corp., Ohio (g)
General Findings & Supply Co., Industrial Div., Mass (a,b,c,f,g)
Grammes, L.F. & Sons, Inc., Pa (a,b,g)
Greene, G.G. Corp., Pa (g)
Hayden Wire Works, Inc., Mass (g)
Hodges, William & Co., Inc., Pa (g)
Hunter Spring Co., Div. of American Machine & Metals, Inc., Pa (a,b,f,g)
Industrial Precision Products, Ill (a,b,c,e,f,g,h,j)
Judd Industries, Inc., Ohio (a,f,g)
King Laboratories, Inc., NY (a,f,g)
Klise Mfg. Co., Mich (b,g)
Laclede Steel Co., Mo (g)
Larkin Specialty Mfg. Co., Calif (a,b,f,g)
Leach & Garner Co., Industrial Div., Mass (a,b,f)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (a,b,e,g)
Melco Wire Products, Calif (a)
Metal Textile Corp., NJ (a,b,c,f,g,h)
Mid-West Wire Products Co., Inc., Mich (g)
Morse, Fred W. Co., RI (a,b,g)
Newark Wire Cloth Co., NJ (a,b,f,g,h)
Northwestern Steel & Wire Co., Ill (g)
Ormond Mfg. Co., Inc., NJ (a,b,c,f,g,h)
Parker Metal Goods Co., Mass (a,b,c,g)
Penrod, Floyd & Sons Tool & Engineering Corp., Ind (g)
Pittsburgh Steel Co., Pa (g)
Reliable Spring & Wire Forms Co., Ohio (a,b,e,f)
Republic Steel Corp., Ohio (g)
Riverside-Alloy Metal Div., H.K. Porter Co., Inc., NJ (b,f,g)
Robertson Steel & Iron Co., Ohio (a,b,g)
Rockford Bolt & Steel Co., Ill (g)
Roebling's, John A. Sons Div., Colorado Fuel & Iron Corp., NJ (g)
Rolock Inc., Conn (a,b,f,g)
Scovill Mfg. Co., Mill Products Div., Conn (a,b,c,f,g)
Servwell Products Co., Ohio (f)
Simonsen Metal Products Co., Ill (a)
Star Heel Plate Co., Inc., NJ (g)
Steel Heddle Mfg. Co., Pa (a,b,c,e,f,g)
Superior Mfg. Co., Pa (a,c,g,j)
Sylvania Electric Products, Inc., Parts Div., Pa (a,b,c,d,f,g)
Titchener, E.H. & Co., NY (a)
Turner & Seymour Mfg. Co., Conn (a,b,g)
United Wire & Supply Corp., RI (a,b)
U.S. Steel Supply Div., U.S. Steel Corp., Ill (g)
Wal-Mar Corp., Ill (a,b,c,g)
Ward, H.H. Co., Pa (a,b,c,f,g,j)
Washington Mfg. Co., Iowa (g)
Waterbury Buckle Co., Conn (a,b,g)
Wesco Spring Co., Ill (g)
Whyte, Oliver Co., Inc., Mass (g)
Wilder Mfg. Co., Inc., Calif (a,b,g)
Wire and Iron Products, Inc., Mich (a,b,c,f,g)
Wood, John Co., Minn (g)
Worth Co., Wis (a,b,e,g)

Wood—Balsa

Balsa Equador Lumber Corp., NY
Bogert & Hopper, Inc., NY
Emery, George D. Co., NY
Foss Mfg. Co., Id
Gamble Brothers, Inc., Special Products Div., Ky
General Veneer Mfg. Co., Calif
International Balsa Corp., NJ
Monteath, J.H. Co., NY
Pollack, Robert Co., Calif
Sterling Models, Pa
Technical Ply-Woods Sales, Ill
Testor Chemical Co., Ill

Wood—Composition Board

Allied Chemical Corp., Plastics Div., NY
Armstrong Cork Co., Pa
Artyle Industries, Inc., Ohio
Balsa Equador Lumber Corp., NY
Celotex Corp., Ill
Diamond Lumber Co., Ore
Durel, Inc., Iowa
Formica Corp., Sub. of American Cyanamid Co., Ohio
Gamble Brothers, Inc., Special Products Div., Ky
Georgia-Pacific Corp., Ore
Hardboard Div., Evans Products Co., Ore
Johns-Manville Corp., NY
Long-Bell Div., International Paper Co., Wash
Masonite Corp., Ill
National Starch & Chemical Corp., Structural Products Div., NY
Pope & Talbot, Inc., Ore
Reynolds Aluminum Supply Co., Ga
Roddis Plywood Corp., Wis
Simpson Timber Co., Wash
Technical Ply-Woods Sales, Ill
U. S. Gypsum Co., Ill
Wal-Mar Corp., Ill
West Virginia Pulp & Paper Co., NY
Weyerhaeuser Timber Co., Silvatek Products Div., Wash

Wood—Impregnated and/or Compressed

American Polyglas Corp., NJ
Armstrong Cork Co., Pa
Diamond Lumber Co., Ore
Everlite Corp., Wash
Fibron Products, Inc., NY
Formica Corp., Sub. of American Cyanamid Co., Ohio
Gamble Brothers, Inc., Special Products Div., Ky
Georgia-Pacific Corp., Ore
Hardboard Div., Evans Products Co., Ore
Micarta Div., Westinghouse Electric Corp., SC
Parkwood Laminates, Inc., Mass
Permali, Inc., Pa
Ren Plastics Inc., Mich
Reynolds Aluminum Supply Co., Ga
Simpson Timber Co., Wash
Technical Ply-Woods Sales, Ill
West Virginia Pulp & Paper Co., NY
Wood Conversion Co., Minn

Wood—Lignum Vitae

Lignum-Vitae Products Corp., NJ
—Ad p 414

Wood—Plywood

Artyle Industries, Inc., Ohio
Balsa Equador Lumber Corp., NY
Curtis Cos., Inc., Wis
Darlington Veneer Co., SC
Delta Plywood Corp., Ark
Diamond Lumber Co., Ore
Gamble Brothers, Inc., Ky
Georgia-Pacific Corp., Ore
Long-Bell Div., International Paper Co., Wash
Puget Sound Plywood, Inc., Wash
Reynolds Aluminum Supply Co., Ga
Roddis Plywood Corp., Wis
Simpson Timber Co., Wash
Technical Ply-Woods Sales, Ill
Timber Products Co., Ore
U. S. Plywood Corp., NY
West Virginia Pulp & Paper Co., NY

Wool Felts

(see Felts)

Wrought Iron

(see Iron)

Zinc and Its Alloys

Advance Stamping Co., Mich (dd)
Allied Research Products, Inc., Md (n)
Alpha Metals, Inc., NJ (v)
American Metal Climax, Inc., NY (o,w)
American Nickel Alloy Mfg. Corp., NY (q,w)
American Silver Co., NY (v,dd)
American Smelting & Refining Co., NY (n,v,w)
American Zinc Sales Co., Mo (n,o,q,w,z)
Anchor Metal Co., Inc., NY (w)
Apex Smelting Co., Ill (w)
Belmont Smelting & Refining Works, Inc., NY (n,o,v,w,z,aa,bb,cc,dd,ff)
Bunker Hill Co., Calif (n,o,z,cc,dd)
Cerro Sales Corp., Sub. of Cerro Corp., NY (w)
Chicago Smelting & Refining Corp., Ill (w)
Clark Perforating Co., Mich (cc)
Dixon Sintaloy, Inc., Conn (o)
Duane Specialties, Ltd., NJ (w)
Eagle-Picher Co., Ohio (q,aa)
Empire Metal Co., NY (n,o,q,v,w,z,bb,cc,dd,ff)
Federated Metals Div., American Smelting & Refining Co., NY (n,w)
Fox Products Co., Pa (n)
General Smelting Co., Pa (n,w,aa)
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (ff)
Hettleman, K. & Sons, Inc., Md (w)
Hi-Grade Alloy Corp., Ill (n,o)
Hodgson Foundry Co., Ill (n)
Hull, R.O. & Co., Inc., Ohio (n)
Illinois Smelting & Refining Co., Ill (o,w,z,aa,bb,cc,dd)
Illinois Zinc Co., Div. of Hydrometals, Inc., Ill (w,z,bb,cc,dd)
International Minerals and Metals Corp., NY (w)
Jordan Co., Ill (w)
Kirk, Morris P. & Son, Calif (n)
Lavin, R. & Sons, Inc., Ill (n,w)
Matthiessen & Hegeler Zinc Co., Ill (n,o,q,v,w,z,aa,bb,cc,dd)
McGean Chemical Co., Ohio (n,z,aa)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metco Inc., NY (ff)
Modern Plating Corp., Ill (n)
National Galvanizing Co., Pa (w)
National Lead Co., NY (n,o,q,w,z,bb,cc,dd,ee)
Nesor Alloy Products Co., NJ (ff)
New England Smelting Works, Inc., Mass (o,w)
New Jersey Metals Co., NJ (n)
New Jersey Zinc Co., NY (n,w,z,aa,dd)—Ad pp 406-407
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Peerless Alloy Co., Colo (o,w)
Pittsburgh Smelting & Refining Co., Pa (w)
Plasmadyne Corp., Calif (aa)
Republic Metals Co., Inc., NY (n,o,w)
Rotometals, Calif (n,o,w,aa,bb,cc,dd,ff)
St. Joseph Lead Co., NY (w)—Ad p 155
Sall, George Metals Co., Inc., Pa (n,w)
Security Sash & Screen Co., Mich (cc)
Stevens, Frederic B., Inc., Mich (n)
Udylite Corp., Mich (n)
U. S. Reduction Co., Ind (w)
U. S. Smelting, Refining & Mining Co. NY (w)
Wall Colmonoy Corp., Mich (aa)
White Metal Rolling & Stamping Corp., NY (o,bb,ff)
Whitehead Metal Products Co., Inc., NY (cc,dd,ee)

Zirconium and Its Alloys

Allegheny Ludlum Steel Corp., Pa (o,q,v,w,z,bb,cc,dd,ee,ff)
American Silver Co., NY (v,dd,ee,ff)
Babcock & Wilcox Co., Tubular Products Div., Pa (ee)
Belmont Smelting & Refining Works, Inc., NY (aa)
Bishop, J. & Co. Platinum Works, Pa (ee)
Brooks & Perkins, Inc., Mich
Carborundum Co., NY (o,q,v,w,z,bb,cc,dd,ee,ff)
Carborundum Metals Co., NY (o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Carpenter Steel Co., Alloy Tube Div., NY (ee)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (ee)

Columbia National Corp., Pa (w)
Crucible Steel Co. of America, Pa (ee)
Damascus Tube Co., Pa (ee)
Esco Corp., Ore (o,q,w,bb,ee)
Foote Mineral Co., Pa (o,v,aa,bb,ee, ff)
General Electric Co., Metallurgical Products Dept., Mich (q,w,aa,bb,cc, dd)
Hamilton Watch Co., Precision Metals Div., Pa (v,bb,cc,ff)
Hardy, Charles, Inc., NY (aa)
Harvey Aluminum, Calif (o,q,v,w,z, bb,cc,dd,ee,ff)
Hayden Wire Works, Inc. Mass (aa)
Johnston & Funk Titanium Corp., Ohio (bb,ff)
King Laboratories, Inc., NY (aa)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,dd,ee,ff)
Metal Forming Corp. Div., Vanadium-Alloys Steel Co., Pa (ee)
Metal Hydrides, Inc., Mass (aa)
Metallizing Co. of Los Angeles, Inc., Calif (cc,ff)
Michigan Seamless Tube Co., Mich (ee)
National Lead Co., NY (o,q,w,z,bb,cc, dd)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Nuclear Materials & Equipment Corp., Pa (o,w,aa)
Nuclear Metals, Inc., Mass (w,bb,dd, ee,ff)
Oregon Metallurgical Corp., Ore (w,ee)
Plasmadyne Corp., Calif (aa)
Plasmatech Div., Valley Metallurgical Processing Co., Conn (aa)
Reactive Metals, Inc., Ohio (o,q,v,w,z, bb,cc,dd,ee,ff)
Republic Steel Corp., Steel & Tubes Div., Ohio (ee)
Rodney Metals, Inc., Mass (v)
Superior Steel Corp., Pa (dd)
Superior Tube Co., Pa (ee)—Ad pp 424-425
Texas Instruments, Inc., Metals & Controls Div., Mass (v,cc,dd,ee,ff)
Trent Tube Co., Pa (ee)
Tube Reducing Corp., NJ (ee)
Vitro Chemical Co., NY
Wah Chang Corp., NY (w)—Ad p 152
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,w,z,bb,ce, dd,ee)
Wolverine Tube Div., Calumet & Hecla, Inc., Mich (ee)
Zirconium Metals Corp., Sub. of National Lead Co., NY (o,q,v,w,z,aa,bb,cc,dd,ff)—Ad p 409

ADDRESSES OF SUPPLIERS

a

A & A Die Casting Co., 12901 S Western Ave., Gardena, Calif.
ACF Industries, Inc., 30 Church St., New York 8, N.Y.
American Car & Foundry Div., 750 3d Ave., New York 17, N.Y.
aal:Bee Plastic Co., 4505 W Jefferson Blvd., Los Angeles 16, Calif.
Abalon Precision Mfg. Corp., 540 Casanova St., New York 59, N.Y.
Abbott Ball Co., 1074 New Britain Ave., Hartford 10, Conn.
Abbott Products, Inc., 150-50 12th Ave., Whitestone 57, N.Y.
Abco Aluminum & Brass Works, 5235 Griggs Rd., Houston 21, Tex.
Abegg & Reinhold Co., 2533 E 26th St., Los Angeles 58, Calif.
Able Tool & Engineering Co., 865 N Sangamon St., Chicago 22, Ill.
Accurate Anodizing Corp., 4100 W Lake St., Chicago 24, Ill.
Accurate Die Casting Co., 3089 E 80th St., Cleveland 4, Ohio
Accurate Metal Weather Strip Co., Inc., 725 S Fulton Ave., Mt. Vernon, N.Y.
Accurate Molding Corp., 35-20 48th Ave., Long Island City 1, N.Y.
Ace Metal Spinning, 4922 S Western Ave., Chicago 9, Ill.
Ace Plastic Co. (Ad p 432) 91-30 Van Wyck Expy., Jamaica 35, N.Y.
Ace Wire Spring & Form Co., Inc., Tunnel Way, McKees Rocks, Pa.
Acheson Colloids Co., 1635 Washington, Pt. Huron, Mich.
Acme Aluminum Foundry Co., 6831 S Bell Ave., Chicago, Ill.
Acme Foundry & Machine Co., Coffeyville, Kan.
Acme Foundry & Machine Co., 400 E Frisco, Blackwell, Okla.
Acme Galvanizing Co., 1733 17th St., Oakland 7, Calif.
Acme Mfg. & Gasket Co., 730-40 N 41st St., Philadelphia 4, Pa.
Acme Metal Spinning, Inc., 98 43rd Ave., NE, Minneapolis 21, Minn.
Acme Plating Co., 1563 E 21st St., Cleveland 14, Ohio
Acme Precision Products, Inc., 215 N Findlay St., Dayton 3, Ohio
Acme Resin Corp., 1401 Circle Ave., Forest Park, Ill.
Acme Specialties, Inc., 4326 N American St., Philadelphia 40, Pa.
Acme Stamping & Wire Forming Co., 201-209 Corliss St., Pittsburgh 20, Pa.
Acme Steel Co., Acme Steel Products Div., 135th St. & Perry Ave., Chicago 27, Ill.
Acme Steel & Malleable Iron Works, Buffalo 7, N.Y.
Acme Tube, Inc., 212 Colt St., Irvington 11, N.J.
Acme-Newport Steel Co., 9th & Lowell Sts., Newport, Ky.
Acorn Sheet Metal Mfg. Co., Inc., 3750 N. Powell Ave., Franklin Park, Ill.
Acoustica Associates, Inc., Universal Dynamics Div., 130 Los Aguajes Ave., Santa Barbara, Calif.
Acro Metal Stamping Co., 332 E Reservoir, Milwaukee 12, Wis.
Acushnet Process Co., Belleville Ave., New Bedford, Mass.
Adams Engineering Co., Inc., 19300 Biscayne Blvd., Miami, Fla.
Adams, I. G., Metalware Co., 2947 Delmar Pl., St. Louis, Mo.
Adams Plastic Products, Finlay & Providence Sts., Cincinnati, Ohio
Adhesive Products Corp., 1660 Boone Ave., New York 60, N.Y.
Adirondack Steel Casting Co., Watervliet, N.Y.
Admiral Corp., Molded Prods. Div., P.O. Box 338, West Chicago, Ill.
Advance Aluminum Castings Corp., 2742 W 36th Place, Chicago 32, Ill.
Advance Foundry Co., 107 Seminary Ave., Dayton, Ohio
Advance Galvanizing Co., 5332 Alcoa Ave., Los Angeles 58, Calif.
Advance Pressure Castings, Inc., 20 Wythe Ave., Brooklyn 11, N.Y.
Advance Screw Products Co., Inc., 3767 S Kinnickinnic Ave., Milwaukee 7, Wis.
Advance Stamping Co., 12025 Dixie Ave., Detroit 39, Mich.
Advance Tool & Die Casting Co., 3760 N Holton St., Milwaukee 12, Wis.
Aelco Foundries, Inc., 1980 S 4th St., Milwaukee 4, Wis.
Aerojet-General Corp., Structural Materials Div., 6352 N. Irwindale St., Azusa, Calif.
Aerolite Electronics Corp., 2207 Summit Ave., Union City, N.J.
Aerolite Extrusion Co., 4605 Lake Park, Youngstown, Ohio
Aetna Felt Co., Inc., 204 Centre St., New York 13, N.Y.
Aetna Steel Co., P.O. Box 2090, Jacksonville 3, Fla.
Affiliated Screw Products Co., 3800 Wesley Terrace, Schiller Park, Ill.
African Metals Corp., 25 Broad, New York 4, N.Y.
Air Reduction Co., Inc., 150 E 42nd St., New York 17, N.Y.
  Air Reduction Chemical and Carbide Co. Div., 150 E 42nd St., New York, N.Y.
  Air Reduction Sales Co., 150 E 42nd St., New York 17, N.Y.
  Colton Chemical Co., 1747 Chester Ave., Cleveland 14, Ohio
Akron Porcelain Co., 2723 Cory Ave., Akron 14, Ohio
Akron Standard Mold Co., Lecromelt Casting Div., Houston St., Barberton, Ohio
Alabama Metallurgical Corp., P.O. Box 38, Selma, Ala.
Alabama Wire Co., Inc., Terrace St., Florence, Ala.
Aladdin Transparent Packaging Corp., 608 Main St., Westbury, N.Y.
Alan Wood Steel Co., Conshohocken, Pa.
Albany Car Wheel Co., Inc., 185 Broadway, Menands, N.Y.
Albany Felt Co., Broadway, Albany 1, N.Y.
Albany Novelty Mfg. Co., 107 W Canton St., Boston 18, Mass.
Albany Products Co., Inc., 351 Connecticut Ave., South Norwalk, Conn.
Albert Lea Foundry Co., 910 Marshall Ave., Albert Lea, Minn.
Albert Pipe Supply Co., Inc., 101 Varick Ave., Brooklyn 37, N.Y.

Albion Malleable Iron Co., 601 N Albion St., Albion, Mich.
Albraco Metals Corp., 649 Van Sinderen Ave., Brooklyn 7, N.Y.
Albright Son & Co., 123 N Front St., Allentown, Pa.
Alcasco Foundry, 14023 Loomis Ave., Harvey, Ill.
Alchemize Corp., 625 S Kolmar Ave., Chicago 24, Ill.
Alco Products, Inc., 30 Church St., New York, N.Y.
Alcylite Plastics & Chemical Corp., 23874 N Pine St., Newhall, Calif.
Aldan Rubber Co., Tioga & Salmon Sts., Philadelphia 34, Pa.
Alden Products Co., 209 N Main St., Brockton 64, Mass.
Alexander, E. P. & Son, Clifton Heights, Pa.
Alleg'eny Foundry Co., 915 Behan St., Pittsburgh 33, Pa.
Allegheny Ludlum Steel Corp., Oliver Bldg., Pittsburgh 22, Pa.
Allegheny Plastics, Inc., Rt. 51 & Thorn Run Rd., Coraopolis, Pa.
Allen Mfg. Co., Drawer 570, Hartford 1, Conn.
Allen-Stevens Corp., 33-53 62nd St., Woodside 77, N.Y.
All-Form Metal Products Co., 13000 Athens Ave., Cleveland 7, Ohio
AllianceWare, Inc., AllianceWall Div., Box 809, Alliance, Ohio

Allied Chemical Corp. (Ad pp 357-360)
61 Broadway, New York 6, N.Y.
General Chemical Div., 40 Rector St., New York 6, N.Y.
Plastics Div., 40 Rector St., New York 6, N.Y.
Solvay Process Div., 61 Broadway, New York 6, N.Y.

Allied Machine Products Co., 6174 Concord Ave., Detroit 11, Mich.
Allied Metal Products Co., 81 Prescott St., Worcester 6, Mass.
Allied Products Corp., 12677 Burt Rd., Detroit 23, Mich.
Allied Research Products, Inc., 4004 W Monument St., Baltimore 3, Md.
Allied Resinous Products, Inc., Clark & Whitney Sts., Conneaut, Ohio
Allied Steel Castings Co., 1225 W 120th St., Chicago 43, Ill.
Allied Tube Corp., Bristol & Bath Sts., Philadelphia 37, Pa.
Allis-Chalmers Mfg. Co., 501 N 3rd St., La Crosse, Wis.
Allmetal Screw Products Co., Inc., 821 Stewart Ave., Garden City, N.Y.
All-Metals Precision Casting Corp., 22 School St., Yonkers, N.Y.
Alloy Cast Steel Co., Rose Ave., Marion, Ohio
Alloy Engineering & Casting Co., 1700 W Washington St., Champaign, Ill.
Alloy Metal Powders, Inc., 238 Eagle St., Brooklyn, N.Y.
Alloy Metal Products Inc., 2333 Rockingham Rd., Davenport, Iowa
Alloy Precision Castings Co., 3857 W 150th St., Cleveland 11, Ohio

Alloy Products Corp. (Ad p 434)
1045 Perkins Ave., Waukesha, Wis.

Alloy Rods Co., Lincoln Hwy. W, York, Pa.
Alloy Steel Casting Co., County Line Rd., Southampton, Pa.
Alloy Steel & Metals Co., 1848 E 55th St., Los Angeles 58, Calif.
Alloy Surfaces Co., Inc., 100 S Justison St., Wilmington 1, Del.
All-State Welding Alloys Co., Inc., 249 Ferris Ave., White Plains, N.Y.
Almco Steel Products Corp., Wabash Ave., Bluffton, Ind.
Almont Mfg. Co., 335 E 3rd St., Imlay City, Mich.
Alofs Mfg. Co., 345 32nd St. SW, Grand Rapids 8, Mich.
Alox Mfg. Co., 6160 Maple Ave., St. Louis 14, Mo.

Alpha Metals, Inc., 56 Water St., Jersey City, N.J.
Alphaloy Corp. Div., 2250 S Lumber St., Chicago, Ill.
Alpha Plastics, Inc., 78 Okner Pkwy., Livingston, N.J.
Alpha Wire Corp., 200 Varick St., New York 14, N.Y
Alpha-Molykote Corp., 65 Harvard Ave., Stamford, Conn.
Alten Foundry & Machine Works, Inc., 2000 W Wheeling St., Lancaster, Ohio
Aluminium Ltd. Sales, Inc., 630 5th Ave., New York 20, N.Y.
Aluminum Alloys Corp., 6650 W Walton Ave., Detroit 10, Mich.
Aluminum Billets, Inc., 3786 Oakwood Ave., Youngstown, Ohio
Aluminum Casting & Engineering Co., 2039 S Lenox St., Milwaukee 7, Wis.
Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh 19, Pa.
Industrial Foil Div., 1655-E Alcoa Bldg., Pittsburgh 19, Pa.
Aluminum Extrusions, Inc., 815 Shepherd St., Charlotte, Mich.
Aluminum Finishing Corp., 1012 E 21st St., Indianapolis 2, Ind.
Aluminum Foils Co., P.O. Box 540, Jackson, Tenn.
Aluminum Goods Mfg., Manitowoc, Wis.
Aluminum Industries, Inc., 3670 Werk Rd., Cincinnati, Ohio
Aluminum & Magnesium, Inc., 1 Huron St., Sandusky, Ohio
Aluminum Permanent Mold Co., 1054 Front Ave., NW, Grand Rapids 4, Mich.
Aluminum Specialty Co., 16th & Wollmer Sts., Manitowoc, Wis.
Amalgamated Steel Corp., 7835 Broadway Ave., Cleveland 5, Ohio
Ambassador Plastics & Mfg. Corp., 308 W Erie, Chicago 10, Ill.
Ambrit Industries, Inc., 1268 Los Angeles St., Glendale 4, Calif.

Amchem Products, Inc. (Ad p 344)
Ambler, Pa.

Amco Plastic Pipe Co., 2002 Davis St., San Leandro, Calif.
Amerace Corp., 200 W 42nd St., New York, N.Y.
American Hard Rubber Co. Div., Ace Rd., Butler, N.J.
Supplex Co. Div., 225 North Ave., Garwood, N.J.
Amercoat Corp., 4809 Firestone Blvd., South Gate, Calif.
American Agile Corp., 5461 Dunham Rd., Maple Heights, Ohio
American Aluminum Co., 230 Sheffield St., Mountainside, N.J.
American Aluminum Casting Co., 300 Colt St., Irvington 11, N.J.
American Asbestos Textile Corp., Stanbridge St., Norristown, Pa.
American Brake Shoe Co., 530 5th Ave., New York 36, N.Y.
American Brakeblok Div., 900 W Maple Rd., Troy, Mich.
American Manganese Steel Div., 389 E 14th St., Chicago Heights, Ill.
Amforge Div., 1220 W 119th St., Chicago 43, Ill.
Brake Shoe & Castings Div., 230 Park Ave., New York, N.Y.
Electro-Alloys Div., Taylor St. & Abbe Rd., Elyria, Ohio
Engineered Castings Div., Mountain Read Rd. & NYCRR, Rochester 11, N.Y.
Light Metals Dept., Railroad Ave., Mahwah, N.J.
National Bearing Div., 717 Grant Bldg., Pittsburgh 19, Pa.
American Can Co., Plastics Div., 100 Park Ave., New York, N.Y.

American Cast Iron Pipe Co. (Ad p 398)
2930 16th St. N, Birmingham, Ala.

American Chain & Cable Co., Inc., Reading, Pa.
Acco Steel Casting Div., Tulpehocken St., Reading, Pa.
American Chain Div., 454 E. Princess St., York, Pa.

Page Steel & Wire Div. (Ad p 92)
Box 692, Monessen, Pa.

American Crucible Products Co., 1319 Oberlin Ave., Lorain, Ohio
American Cyanamid Co., 30 Rockefeller Plaza, New York 20, N.Y.
Formica Corp. Sub., 4614 Spring Grove Ave., Cincinnati 32, Ohio
Plastics & Resins Div., 30 Rockefeller Plaza, New York 20, N.Y.
American Electric Cable Co., 181 Appleton St., Holyoke, Mass.
American Electrical Products Co., P.O. Box 200, 653 Lida St., Mansfield, Ohio
American Emblem Co., Inc., P.O. Box 116, Utica 1, N.Y.
American Enka Corp., William Brand-Rex Div., 31 Sudbury Rd., Concord, Mass.
American Fabricated Products Co., 1420 E 20th St., Indianapolis 7, Ind.

American Felt Co. (Ad p 307)
Glenville, Conn.

American Forge & Mfg. Co., P.O. Box 20, McKees Rocks, Pa.
American Foundries Co., 330 2nd St., Milan, Mich.
American Foundry Co., Inc., 1100 S Fibles Ave., Indianapolis 21, Ind.

American Insulator Corp. (Ad p 433)
New Freedom, Pa.

American Latex Products Corp., 3341 W El Segundo Blvd., Hawthorne, Calif.
American Laundry Machinery Co., Rochester, N.Y.
American Lava Corp., Cherokee Blvd. & Mfrs. Rd., Chattanooga 5, Tenn.
American Light Alloys, Inc., 1265 McBride Ave., Little Falls, N.J.
American Machine & Foundry Co., Cleveland Welding Div., W 117th St., Cleveland 11, Ohio
American Machine & Metals Inc., Hunter Spring Co. Div., 1 Spring Ave., Lansdale, Pa.
American Malleable Castings Co., Marion, Ohio
American Manganese Bronze Co., Rhawn & Torresdale Aves., Philadelphia 36, Pa.

American Mannex Corp., Easton Metal Powder Co. Div. (Ad p 418)
900 Line St., Easton, Pa.

American Mfg. Co., 124 Chestnut, Chattanooga 2, Tenn.
American Metal Climax, Inc., 1270 Ave. of the Americas, New York 20, N.Y.
Amco Div., 1270 Ave. of the Americas, New York 20, N.Y.
Climax Molybdenum Div., 1279 Ave. of the Americas, New York 20, N.Y.
American Metal Products Co., 5959 Linsdale Ave., Detroit 4, Mich.
American Metal Products, Inc., 4500 W Mitchell Ave., Cincinnati 32, Ohio
American Metallurgical Products Co., P.O. Box 11068, Pittsburgh 37, Pa.
American Metaseal Corp., 607 65th St., West New York, N.J.
American Molding Co., 2002 Davis St., San Leandro, Calif.
American Molding Powder & Chemical Co., 703 Bedford Ave., Brooklyn 8, N.Y.
American Nickel Alloy Mfg. Corp., 30 Vesey St., New York 7, N.Y.
American Nickeloid Co., 2nd & West Sts., Peru, Ill.

American Petrochemical Corp., Mol-Rez Div., 3134 Calif. St. NE, Minneapolis 18, Minn.
American Pipe & Construction Co., Northwest Div., 518 N E Columbia Blvd., Portland 11, Ore.
American Plastics Corp., 342 Madison Ave., New York 17, N.Y.
American Platinum Works, Newark 5, N.J.
American Polyglas Corp., Broad & 14th Sts., Carlstadt, N.J.
American Potash & Chemical Corp., 3000 W 6th St., Los Angeles 54, Calif.
Lindsay Chemical Div., 258 Ann St., West Chicago, Ill.
American Powdered Metals, Inc., 7-9 Philip Pl., North Haven, Conn.
American Products Corp., 525 S Dearborn St., Chicago 5, Ill.
American Products Mfg. Co., Inc., 8127-33 Oleander St., New Orleans 18, La.
American Reed Co., Inc., 2 S Broadway, Lawrence, Mass.
American Rubber Products Corp., 315 Brighton St., LaPorte, Ind.
American Sanitary Mfg. Co., Box 111, Abingdon, Ill.
American Screw Co., W Main St., Willimantic, Conn.
American Screw Products Co., 5943 Martin Ave., P. O. Box 96, Detroit 10, Mich.
American Sealants Co., 705 N Mountain Rd., Hartford 11, Conn.
American Sheet Metal Works, Inc., 16 Jefferson St., Waterbury 20, Conn.
American Silver Co., Inc., 36-07 Prince St., Flushing 54, N.Y.
American Sinteel Corp., 1019 Saw Mill River Rd., Yonkers, N.Y.
American Smelting & Refining Co., 120 Broadway, New York 5, N.Y.

Continuous Cast Products Div. (Ad p 399)
1160 State St., Barber, N.J.

Federated Metals Div. (Ad p 156)
120 Broadway, New York 5, N.Y.

Lake Asbestos of Quebec, Ltd., Sub. (Ad p 305)
120 Broadway, New York 5, N.Y.

American Solder & Flux Co., 19th & Willard Sts., Philadelphia 40, Pa.
American Stamping Co., 26650 Lakeland Blvd., Cleveland 32, Ohio
American Standard Co., Youngstown Kitchens Div., 605 S Ellsworth Ave., Salem, Ohio
American Steel Foundries, Prudential Plaza, Chicago 1, Ill.
American Steel & Pump Corp., Oklahoma Steel Castings Div., 1200 N Peoria Ave., Tulsa, Okla.
American Synthetic Rubber Corp., 500 5th Ave., New York 36, N.Y.
American Tape Co., 4058 Beaufait Ave., Detroit 7, Mich.
American Tinning & Galvanizing Co., 552 W 12th St., Erie, Pa.
American Valve & Enameling Corp., 2855 S Holt Rd., Indianapolis 41, Ind.

American Viscose Corp. (Ad p 309)
1617 Pennsylvania Blvd., Philadelphia 3, Pa.

American Welding and Mfg. Co., 192 Dietz Rd., Warren, Ohio
American Zinc Sales Co., 1522 Paul Brown Bldg., St. Louis 1, Mo.
American-Marietta Co., 101 E Ontario St., Chicago 11, Ill.
Adhesive, Resin & Chemical Div., 3400 13th Ave., SW, Seattle 4, Wash.
Booty Resineers Div., 42 S 3rd St., Newark, Ohio
Metals Disintegrating Co. Div., P.O. Box 290, Elizabeth 8, N.J.
Presstite Div., 3738 Chouteau Ave., St. Louis, Mo.
Sierra Metals Corp. Sub., 12th St. & W Strong Ave., Wheeling, Ill.

Ames, W. & Co., 417 Communipaw Ave., Jersey City 4, N.J.

Amos-Thompson Corp., Amos Molded Plastics Div., Edinburg, Ind.

Ampco Metal, Inc., 1753 S 38th St., Milwaukee 1, Wis.

Anaconda Co., 25 Broadway, New York 4, N.Y.

Anaconda American Brass Co., 25 Broadway, New York 4, N.Y.

Anaconda Metal Hose Div., 698 S Main St., Waterbury 20, Conn.

Anaconda Aluminum Co., P.O. Box 1654, Louisville 1, Ky.

Anchor Hocking Glass Corp., Lancaster, Ohio

Anchor Metal Co., Inc., 966 Meeker Ave., Brooklyn 22, N.Y.

Anchor Metal Spinning Co., 46 Flehart Ave., Dayton 8, Ohio

Anchor Plastics Co., 36-36 36th St., Long Island City 6, N.Y.

Anderson, O.L. Co., Inc., 1347 E Fort St., Detroit 7, Mich.

Anderson Assoc., Inc., 1702 Wayne St., Toledo 1, Ohio

Anderson-Bolling Mfg. Co., Grand Haven, Mich.

Anesite Co., 3575 Touhy Ave., Chicago 45, Ill.

Anti-Corrosive Metal Products Co., Inc., Castleton-on-Hudson, N.Y.

Apex Foundry, Inc., 633 Lycaste Ave., Detroit 14, Mich.

Apex Smelting Co., 2537 W Taylor St., Chicago 12, Ill.

Apex Steel Corp., Ltd., 6920 E Slauson, Los Angeles 22, Calif.

Apollo Metals, Inc., 6652 S Oak Park Ave., Chicago, Ill.

Appalachian Steel Corp., Schuyler & Page Aves., Lyndhurst, N.J.

Appleton Electric Co., 1701 W Wellington Ave., Chicago 13, Ill.

Applied Instruments, Inc., 25 Will Pl., Brooklyn 7, N.Y.

Approved Mfg. Co., Inc., 307990 W 8th Mile Rd., Farmington, Mich.

Arabol Mfg. Co., 110 E 42nd St., New York 17, N.Y.

Arbonite Corp., 900 N Main St., Doylestown, Pa.

Archer-Daniels-Midland Co., 700 Investors Bldg., Minneapolis, Minn.

Arcos Corp., 1500 S 60th St., Philadelphia 43, Pa.

Ardmore Products, Inc., 194 Aldene Rd., Roselle, N.J.

Argo Plastic Product Co., Inc., 1400 W 10th St., Cleveland 13, Ohio

Argosy Products, Inc., 7504 Carnegie Ave., Cleveland 3, Ohio

Aries Laboratories, Inc., 225 Greenwich Ave., Stamford, Conn.

Arkansas Foundry Co., 1423 E 6th St., Box 231, Little Rock, Ark.

Armco Steel Corp., 703 Curtis St., Middletown, Ohio

Fabricating Div., Middletown, Ohio

National Supply Div., 2 Gateway Center, Pittsburgh 22, Pa.

Sheffield Div., Sheffield Sta., Kansas City 25, Mo.

Armet Alloys, Inc., 4338 Bradley Rd., Cleveland 9, Ohio

Armitage, J. L. & Co., 245 Thomas St., Newark, N.J.

Armor Galvanizing Works, Inc., 580 Market St., San Francisco 4, Calif.

Armor Metal Products Co., 3408 Beekman, Cincinnati 23, Ohio

Armour & Co., Adhesive Div., 1355 W 31st St., Chicago, Ill.

Armstrong Cork Co., West Liberty St., Lancaster, Pa.

Armstrong Products Co., P.O. Box 1-MM, Warsaw, Ind.

Arneson Foundry Co., 3303 66th St., Kenosha, Wis.

Arnold Engineering Co., P.O. Box G, Marengo, Ill.

Arrow Metal Products Corp., 3rd Ave., Haskell, N.J.

Arrow Sintered Products Co., 1900 S Kostner Ave., Chicago 23, Ill.

Arrowhead Products, 2300 Curry St., Long Beach 5, Calif.

Art Wire & Stamping Co. (Ad p 396)
227 High St., Newark 2, N.J.

Artex Felt Co., 62 W 39th St., New York 18, N.Y.

Artmor Plastics Corp., 1003 Oldtown Rd., Cumberland, Md.

Artus Corp., 201 S Dean St., Englewood, N.J.

Artyle Industries, Inc., Box 28, Eaton, Ohio

Arvin Industries, Inc., 13th St., Columbus, Ind.

Arwood Corp., 321 W 44th St., New York 36, N.Y.

Arzt, T. L. Foundry Co., 4020 W Schubert Ave., Chicago 39, Ill.

Asbestos Corp. of America, 31 North Ave., Garwood, N. J.

Asbestos Textile Co., Inc., 165 W Wacker Drive, Chicago 1, Ill.

Asco Sintering Corp., 7799 Telegraph Rd., Los Angeles 22, Calif.

Ashby Mfg. Co., 1601 Woodson Rd., St. Louis 11, Mo.

Asheville-Schoonmaker Mica Co., 900 Jefferson Ave., Newport News, Va.

Ashland Oil & Refining Co., Valvoline Oil Co. Div., 3rd Ave., Freedom, Pa.

Ashtabula Mfg. Co., W 30th St., Ashtabula, Ohio

Associated Engineering & Mfg. Corp., 210 Stonehouse Rd., Glen Ridge, N. J.

Associated Spring Corp., Wallace Barnes Steel Div., 18 Main St., Bristol, Conn.

Atlantic Bag Co., 435 S 5th St., Brooklyn 11, N.Y.

Atlantic Brass Works, Inc., 2600 W Addison St., Chicago 18, Ill.

Atlantic Casting Engineering Corp. (Ad p 412)
810 Bloomfield Ave., Clifton, N.J.

Atlantic Foundry Co., 182 Beaver St., Akron 4, Ohio

Atlantic India Rubber Works, Inc., 569 W Polk St., Chicago 7, Ill.

Atlantic Powdered Metals, Inc., 38 Park Row, New York 38, N.Y.

Atlantic Steel Co., P.O. Box 1714, Atlanta 1, Ga.

Atlantic Steel Castings Co., 6th & Lloyd Sts., Chester, Pa.

Atlas Brass Foundry, 1901 Santa Fe Ave., Los Angeles 21, Calif.

Atlas Chemical Industries, Inc., Wilmington 99, Del.

Atlas Drop Forge Co., 209 W Mt Hope Ave., Lansing 4, Mich.

Atlas Foundry Co., 3600 W 69th St., Cleveland 2, Ohio

Atlas Foundry & Machine Co., 3012 S Wilkeson St., Tacoma, Wash.

Atlas Foundry & Mfg. Co., 3701 Collins Ave., Richmond, Calif.

Atlas Galvanizing Co., 2639 Leonis Blvd., Los Angeles 11, Calif.

Atlas Metal Parts Co., 3232 N 31st St., Milwaukee 16, Wis.

Atlas Mineral Products Co., 161 Weber St., Mertztown, Pa.

Atlas Steel Construction Co., 20 Vesey St., New York 7, N.Y.

Auburn Foundry, Inc., W 11th St., Auburn, Ind.

Auburn Mfg. Co. (Ad p 318)
20 Stack St., Middletown, Conn.

Auburn Plastic Engineering, 4916 S Loomis St., Chicago 9, Ill.

Auburn Plastics, Inc., 48 Canoga St., Auburn, N.Y.

Auburn Rubber Co., Inc., W 11th St., Auburn, Ind.

Auburn Spark Plug Co., Inc., Special Products Div., 89 York St., Auburn, N.Y.

Auel Industries, Herminie, Pa.

Auld, D. L. Co., 5th Ave. & 5th St., Columbus, Ohio

Aurora Metal Co., 614 W Park Ave., Aurora, Ill.

Aurora Refining Co., P.O. Box 88, Aurora, Ill.

Autel Electronics Co., Precision Machine & Welding Div., 1122 E St. George Ave., Linden, N.J.

Auto Specialties Mfg. Co., 643 Graver St., St. Joseph, Mich.

Automatic Nut Co., Lebanon, Pa.

Automotive Rubber Co., Inc., 12554 Beech Rd., Detroit, Mich.

Avco Mfg. Corp., 420 Lexington Ave., New York, N.Y.

New Idea Div., 420 Lexington Ave., New York, N.Y.

Avery Label Co., 1616 S California Ave., Monrovia, Calif.

Aviation Developments, Inc., 210 S Victory Blvd., Burbank, Calif.

Avins Industrial Products Corp., 50 Broadway, New York 4, N.Y.

AviSun Corp. (Ad pp 226-227)
1608 Walnut St., Philadelphia 3, Pa.

Avondale Co., 260 Happ Rd., Northfield, Ill.

Avril, G. A. Co., Este Ave. & B&O R.R., Cincinnati, Ohio

b

B. B. Chemical Co., Bostik Dept. (Ad p 464)
784 Memorial Dr., Cambridge 39, Mass.

B & T Metals Co., 425 W Town St., Columbus 16, Ohio

Babbitt Chemical Co., Inc., 38 Prospect, New Bedford, Mass.

Babcock & Wilcox Co. (Ad p 423)
Tubular Products Div., Beaver Falls, Pa.

Babson Dow Mfg. Co., 64 Fulda St., Roxbury, Boston 19, Mass.

Backus Novelty Co., 411 Water St., Smethport, Pa.

Bacon Felt Co., 427 W Water St., Taunton, Mass.

Badger Aluminum Extrusions, 950 Georgia Ave., Brooklyn 7, N.Y.

Badger Die Casting Corp., 201 W Oklahoma Ave., Milwaukee 7, Wis

Badger Malleable & Mfg., Co., 223 N Chicago Ave., South Milwaukee, Wis.

Baer, N.S. Co., 1-11 Montgomery St., Hillside 5, N.J.

Baer Bros. Bronze Powder Co., Inc., Nickerson Rd., Ashland, Mass.

Baker & Co., Inc., 113 Astor St., Newark 2, N.J.

Baker, J. T. Chemical Co., 600 N Broad St., Phillipsburg, N.J.

Balas Collet Mfg. Co., 1557 E 27th St., Cleveland 14, Ohio

Baldwin Mfg. Co., 140 Homer St., Waterbury 20, Conn.

Baldwin-Ehret-Hill, Inc., 500 Breunig Ave., Trenton 3, N.J.

Baldwin-Lima-Hamilton Corp., Philadelphia, Pa.

Standard Steel Works Div., Burnham, Pa.

Balsa Ecuador Lumber Corp., 500 5th Ave., New York, N.Y.

Bamberger, Claude P. Inc., 1 Mt. Vernon St., Ridgefield Park, N.J.

Bangor Plastics Inc., Washington St., Bangor, Mich.

Banner Iron Works, 1920 S Kingshighway, St. Louis 10, Mo.

Barber Iron Works, Inc., 301 W 61st St., P.O. Box 6318, Shreveport, La.

Barclay Mfg. Co., 1013 S Council St., Muncie, Ind.

Barnard Foundry Co., Inc., 9 Roseland St., Springfield 7, Mass.

Barnett Foundry & Machine Co., Irvington, N.J.

Bar-Ray Products, 209 25th St., Brooklyn 32, N.Y.

Barrett Chemical Products Co., Inc., 5 Bridge St., Shelton, Conn.

Barrett Varnish Co., 1532 S 50th Court, Cicero 50, Ill.

Barrows Porcelain Enamel Corp., Langdon Farm Rd. & Penn R.R., Cincinnati 17, Ohio

Bart Mfg. Corp., 135 Manchester Pl., Newark 4, N.J.

Barth Smelting Corp., 99-129 Chapel St., Newark 5, N.J.

Bartlett-Thompson Co., Inc., 136 Water St., Wakefield, Mass.

Barton Products Corp., P.O. Box 305, West Bend, Wis.

Bassichis Co., 2323 W 3rd St., Cleveland 12, Ohio

Bassick Co., Howard Ave., Bridgeport, Conn.

Batson-Cook Co., West Point Foundry & Machine Co. Div., West Point, Ga.

Bausch & Lomb Inc., 98462 Bausch St., Rochester 2, N.Y.

Baxter Foundry & Machine Works, Inc., P.O. Box 1016, Boise, Id.

Bay City Electric Steel Casting Co., Trumbull St., Bay City, Mich.

Bay City Forge Co., 1802 Cranberry St., Erie, Pa.

Bay City Foundry Co., 400 Webster St., Bay City, Mich.

Bay Porous Material Co., 753 Loma Verde, Palo Alto, Calif.

Bay State Refining Co., Inc., 8 Montgomery St., Chicopee Falls, Mass.

Bay State Stamping Co., 372 Chandler St., Worcester, Mass.

Bay State Tool & Machine Co., 412 Albany, Springfield 4, Mass.

Bayley Products, Inc., 19155 Glendale Ave., Detroit 5, Mich.

Beacon Metal Mfg. Co., 1127 Atlantic Ave., Brooklyn 16, N.Y.

Bead Chain Mfg. Co., 110 Mountain Grove St., Bridgeport 5, Conn.

Bean, Morris & Co., Hyde Rd., Yellow Springs, Ohio

Bearium Metals Corp., 190 Mill St., Rochester, N.Y.

Beatty Machine & Mfg. Co., 940 150th St., Hammond, Ind.

Beaver Valley Alloy Foundry Co., Atlantic Ave., Monaco, Pa.

Beck, I. & Sons, Inc., 256 Mott St., New York 12, N.Y.

Beck Products Corp., 12255 E 8th Mile Rd., Detroit 5, Mich.

Becker Bros. Carbon Co., 3450 S Laramie Ave., Cicero 50, Ill.

Becker, L. A. Foundry Co., 1201 Hwy. 66, St. Louis 15, Mo.

Beckmann, Inc., 120 Baxter St., New York 13, N.Y.

Bee Chemical Co., 2700 E 170th St., Lansing, Ill.

Behringer Metal Works, Inc., 108 Jabez St., Newark 5, N.J.

Belding Corticelli Industries, 1407 Broadway, New York 18, N.Y.

Belko Corp., Kingsville, Md.

Bellaire Stove Co., 19th & Union Sts., Bellaire, Ohio

Belle City Malleable Iron Co., Racine Steel Castings Div., 1442 Forest St., Racine, Wis.

Belmet Products, Inc., 503 Morgan Ave., New York 22, N.Y.

Belmont Aluminum Extrusion Co., 1228 Belmont Ave., Philadelphia 4, Pa.

Belmont Smelting & Refining Works, 330 Belmont Ave., Brooklyn 7, N.Y.

Beloit Foundry Co., 445 Gardner St., South Beloit, Ill.

Beloit Iron Works, Rock River, Beloit, Wis.

Benada Aluminum Products Co., 37 James St., Girard, Ohio

In contacting suppliers, please mention the Materials Selector Issue

Bendix Aviation Corp., Teterboro, N.J.
Bendix Foundries Div., Teterboro, N.J.
Eclipse-Pioneer Div., Teterboro, N.J.
Benjamin Electric Mfg. Co., Northwest Hwy., Des Plaines, Ill.
Bennett Mfg. Co., 41 Mechanic, Alden, N.Y.
Bergen Point Iron Works, 233 Broadway, New York 7, N.Y.
Bergfels, William & Co., 10 Orchard St., Newark 2, N.J.
Berry Bros., 211 Leib St., Detroit 7, Mich.
Beryl Ores Co., 12900 W 100 Ave., Arvada, Colo.
Beryllium Corp. (Ad p 159)
P.O. Box 1462, Reading, Pa.
National Precision Casting Corp. Div., P.O. Box 396, Paoli, Pa.
Bessemer Galvanizing Works, Bessemer, Ala.
Bethandale Corp., 24040 Lakeland Blvd., Cleveland 23, Ohio
Bethlehem Steel Co., 701 E 3rd St., Bethlehem, Pa.
Better Finishes & Coatings, Inc., 270 Doremus Ave., Newark, N.J.
Bettinger Corp., Gore St., Waltham, Mass.
Bevan Co., 400 N Arden Dr., El Monte, Calif.
Bickford, F. H., Co., 1529 S Broadway, Dayton 8, Ohio
Biddle Screw Products Co., S Main, Sheridan, Ind.
Bierman-Everett Foundry Co., 135 S 20th St., Irvington, N.J.
Biersach & Niedermeyer Co., 1937 N Hubbard St., Milwaukee 12, Wis.
Biggs, Carl H. Co., Inc., 1547 14th St., Santa Monica, Calif.
Bignall Co., 28 Wasson St., Buffalo 10, N.Y.
Billings & Spencer Co., 1 Laurel St., Hartford 1, Conn.
Bingham-Herbrand Corp., Herbrand Div., Lake & Stone Sts., Fremont, Ohio
Binkley Co., 100 Elm St., Warrenton, Mo.
Birchwood Chemical Co., 4500 W 44th St., Minneapolis 24, Minn.
Bird, Richard H. Co. Inc., 1 Spruce St., Waltham 54, Mass.
Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa.
Bischoff Chemical Corp., 220 Miller Rd., Hicksville, N.Y.
Bishop, J. & Co. Platinum Works (Ad p 394)
E King St., Malvern, Pa.
Bishopric Products Co., 4413 Este Ave., Cincinnati 32, Ohio
Bisonite Co., Inc., P.O. Box 84, Kenmore Sta., Buffalo 17, N.Y.
Biwax Corp., 3445 Howard St., Skokie, Ill.
Blacher, B., 752 Broadway, New York 3, N.Y.
Blacher Bros., Inc., 299 Carpenter St., Providence 9, R.I.
Black Bear Co., Inc., 44-45 23rd St., Long Island City 1, N.Y.
Black-Clawson Co., 1700 Grand Ave., Middletown, Ohio
Shartle Div., 2nd & Vine Sts., Hamilton, Ohio
Blaco Mfg. Co., 6541 Euclid Ave., Cleveland 3, Ohio
Blair Strip Steel Co., 1209 Butler Ave., New Castle, Pa.
Blake & Johnson Co., Waterville 48, Conn.
Blakeslee Forging Co., Plant Pl., Plantsville, Conn.
Blank, Arthur & Co., Inc., 33 Cummington St., Boston 15, Mass.
Blaw-Knox Co., 300 6th Ave., Pittsburgh 23, Pa.
Blickman, S., Inc., 536 Gregory Ave., Weehawken, N.J.
Bliss, E. W. Co., Mackintosh-Hemphill Div., 901 Bingham St., Pittsburgh 3, Pa.
Bliss & Laughlin, Inc., 281 E 155th St., Harvey, Ill.
Blossom Mfg. Co., Inc., 2337 McDonald Ave., Brooklyn, N.Y.
Boatwright Paint & Varnish Works, Inc., P.O. Box 306, Norcross, Ga.
Boehm Screw Products Co., 7100 W Jefferson, Detroit 17, Mich.
Bogert & Hopper, Inc., 105 W 31st St., New York, N.Y.
Bohn Aluminum & Brass Corp., 1400 Lafayette Bldg., Detroit 26, Mich.
Bond, Charles Co., 617-623 Arch St., Philadelphia 6, Pa.
Bond International, Inc., 783 S Deacon, Detroit 17, Mich.
Bone Engineering Corp., 701 W Broadway, Glendale 4, Calif.
Bonnell, William L. Co., Inc. Newman, Ga.
Bonney-Floyd Co., 611 Marion Rd., Columbus 7, Ohio
Bonnot Co., 722 Mulberry Rd., SE, Canton 2, Ohio
Booker & Wallestad, Inc., 3336 Gorham Ave., Minneapolis 26, Minn.
Boonton Molding Co., 326 Myrtle Ave., Boonton, N.J.
Booth Felt Co., Inc., 569 18th St., Brooklyn 15, N.Y.
Bocts Aircraft Nut Corp., Newtown Tpke., Norwalk, Conn.
Borden Co., Borden Chemical Co. Div., 350 Madison Ave., New York 17, N.Y.
Borg-Warner Corp., 310 S Michigan Ave., Chicago, Ill.
Atkins Saw Div., 402 S Illinois St., Indianapolis, Ind.
Franklin Steel Div., Franklin, Pa.
Ingersoll Products Div., 1000 W 120th St., Chicago 43, Ill.
Marbon Chemical Div. (Ad pp 231-238)
7165 Chicago Ave., Gary, Ind.
Borkland Mfg. Co., 803 Quarry Rd. at 900 Wabash Rd., Marion, Ind.
Bostitch, Inc., Briggs Dr., East Greenwich, R.I.
Boston Felt Co., 210 South St., Boston 11, Mass.
Boston Gear Works, 14 Hayward St., Quincy 71, Mass.
Boston Metals Co., Baldt Anchor, Chain & Forge Div., 6th & Butler Sts., Chester, Pa.
Both, O.A. Corp., 100 Nickerson Rd., Ashland, Mass.
Bound Brook Bearing Corp. of America, Bound Brook, N.J.
Bowling Green Rubber Co., 4143 Monroe St., Toledo 13, Ohio
Boyles Galvanizing & Plating Co., P.O. Box 187, Hurst, Texas
Bradley Paint Co., 608 W Crawford Ave., Connellsville, Pa.
Bradley & Vrooman Co., 2629 S Dearborn St., Chicago 16, Ill.
Braeburn Alloy Steel Corp., Braeburn, Pa.
Brasco Mfg. Co., Harvey, Ill.
Braun, H. Tool & Instrument Co., Inc., 140 5th Ave., Hawthorne, N.J.
Brewer-Titchener Corp., 111 Port Watson St., Cortland, N.Y.
Bridgeport Brass Co. (Ad p 157)
30 Grand St., Bridgeport 2, Conn.
Cored Forging Div. (Ad p 408)
P.O. Box 119, South Norwalk, Conn.
Hunter-Douglas Aluminum Div., 3016 Kansas Ave., Riverside, Calif.
Bridgeport Moulded Products, Inc., 105 Meadow St., Fairfield, Conn.
Bridgeport Rolling Mills Co., Bridgeport, Conn.
Briel Industries, Inc., Industrial Park, Shelbyville, Ky.
Briggs-Shaffner Co., 500 Brookstown Ave., Winston-Salem, N.C.
Brillion Iron Works, Inc., 200 Park Ave., Brillion, Wis.
Brinkerhoff Brass & Bronze Works, Inc., 57½ Dey St., New York 7, N.Y.
Bristol Brass Corp., 580 Broad St., Bristol, Conn.
Accurate Brass Corp. Sub., Pine & Emmett Sts., Bristol, Conn.
Broadway Mfg. Co., P.O. Box 252, Springdale Rd., Waukesha, Wis.
Broadway Rubber Corp., 728 S 13th St., Louisville, Ky.
Brockway Pressed Metals, Inc., 921 Clark St., Brockway, Pa.
Brom Machine & Foundry Co., 3565 6th St., Winona, Minn.
Bronze & Steel Die Casting Co., Plano, Ill.
Brooks & Perkins, Inc. (Ad p 420)
1950 W Fort St., Detroit 16, Mich.
Brown Corp., 213 Bellevue Ave., Syracuse 1, N.Y.
Brown Rubber Co., Inc., P.O. Box 1000, Lafayette, Ind.
Bruce Foundry & Mfg. Co., 4040 S Evans St., Tecumseh, Mich.
Brunswick Corp., Marion, Va.
Defense Products Div., 1700 Messler St., Muskegon, Mich.
Brush Beryllium Co., 4301 Perkins Ave., Cleveland 3, Ohio
Pennrold Div., 501 Crescent Ave., Reading, Pa.
Buchmann Spark-Wheel Corp., 4-20 47th Ave., Long Island City 1, N.Y.
Buckeye Brass & Mfg. Co., 6410 Hawthorne Ave., Cleveland 3, Ohio
Buckeye Iron & Brass Works, 324 E 3rd St., Dayton 1, Ohio
Buckeye Molding Co., 213 S 3rd St., Miamisburg, Ohio
Buffalo Steel Corp., Tonawanda, N.Y.
Buffalo Weaving & Belting Co., 260 Chandler St., Buffalo 7, N.Y.
Buffalo Wire Works Co., 320 Terrace, Buffalo 2, N.Y.
Bullock, W.J. Inc., P.O. Box 539, Fairfield, Ala.
Bundy Tubing Co., 8109 E Jefferson, Detroit 14, Mich.
Bunker Hill Co., 660 Market St., San Francisco 4, Calif.
Bunting Brass & Bronze Co., 715 Spencer, Toledo 1, Ohio
Burgess-Norton Mfg. Co., 737 Peyton St., Geneva, Ill.
Burkart, F., Mfg. Co., 4900 N 2nd St., St. Louis 7, Mo.
Burkhardt Steel Co., 869 S Broadway, Denver 9, Colo.
Burwood Products Co., Airport Dr., Traverse City, Mich.
Busada Mfg. Corp. (Ad p 415)
32-21 Downing St., Flushing, N.Y.
Busch, J.C. Co., 17 W 54th St., New York 19, N.Y.
Butler Engine & Foundry Co., Inc., 151 S Monroe, Butler, Pa.
Butler Mfg. Co., 7309 E 13th St., Kansas City, Mo.
Button Corp. of America, 49 Dickerson St., Newark 3, N.J.
Byers, A. M., 1610 Clark Bldg., Pittsburgh 22, Pa.
Byrd Plastics, Inc., 2953 W 12th St., Erie, Pa.

C

C. E. M. Co. Inc., 3 School St., Danielson, Conn.
CFI Corp., Cottage Pl., Mineola, N.Y.
C & G Screw Machine Products Co., P.O. Box 308, Carmel, Ind.
Cadillac Malleable Iron Co., 10th St., Cadillac, Mich.
Cadillac Plastic & Chemical Co., 15111 2nd Ave., Detroit, Mich.
Caldwell, W. E. Co., 2020 Brook St., Louisville 8, Ky.
Calfibe Co., Inc., P.O. Box 832, Redlands, Calif.
California Drop Forge Co., 1033 Alhambra Ave., Los Angeles 12, Calif.
California Metal Enameling Co., 6904 E Slauson Ave., Los Angeles 22, Calif.
California Perforated Screen Co., 345-347 Folsom St., San Francisco 5, Calif.
Callahan Zinc-Lead Co., Inc., Flexaust Div., 100 Park Ave., New York 17, N.Y.
Calorizing Co., P.O. Box 8742, Pittsburgh 21, Pa.
Calumet & Hecla, Inc., 13 Calumet Ave., Detroit 9, Mich.
Calumet Div., 11 Calumet Ave., Calumet, Mich.
Wolverine Tube Div. (Ad p 403)
17258 Southfield Rd., Dept. M, Allen Park, Mich.
Calumet Steel Castings Corp., 1636 Summer St., Hammond, Ind.
Cambridge Wire Cloth Co., Cambridge, Md.
Camcar Screw & Mfg. Co., 600 18th Ave., Rockford, Ill.
Cameron Iron Works, Inc., Special Products Div. (Ad p 417)
P.O. Box 1212, Houston 1, Tex.
Camfield Fiberglass Plastics, Inc., N Centennial St., Zeeland, Mich.
Camloc Fastener Corp., 22 Spring Valley Rd., Paramus, N.J.
Campro Co., 3131 Columbus Rd., NE, Canton 1, Ohio
Canfield, H.O. Co., Box 529, Clifton Forge, Va.
Cannon-Muskegon Corp., 2875 Lincoln St., Muskegon, Mich.
Canton Malleable Iron Co., 2408 13th NE, Canton, Ohio
Capac Mfg. Corp., Capac, Mich.
Capitol Chemical Co., 4501 W Haddon Ave., Chicago 51, Ill.
Capitol Products Corp., Mechanicsburg, Pa.
Caradco Corp., Durel Div., 7th & White, Dubuque, Iowa
Carbo Tool & Die Co., 219 Howland St., Fremont, Ohio
Carboline Co., 32 Hanley Ct., St. Louis 17, Mo.
Carbone Corp., 400 Myrtle Ave., Boonton, N.J.
Carborundum Co., Niagara Falls, N.Y.
Refractories Div., Perth Amboy, N.J.
Carborundum Metals Co., P.O. Box 32, Akron, N.Y.
Carey, Philip Mfg. Co., 320 S Wayne Ave., Lockland, Cincinnati 15, Ohio
Carleton Screw Products Co., 2424 Hiawatha Ave S, Minneapolis 4, Minn.
Carlon Products Corp., 10225 Meech Ave., Cleveland 5, Ohio
Carlson, G.O. Inc., Thorndale, Pa.
Carolina Asbestos Co., Davidson, N.C.
Carondelet Foundry Co., 2101 S Kingshighway, St. Louis 10, Mo.
Carpenter Steel Co., 101 W Bern St., Reading, Pa.
Alloy Tube Div., Springfield Rd., Union, N.J.
Webb Wire Div., 17 Liberty St., New Brunswick, N.J.
Carroll, J.B. Co., 319 N Albany Ave., Chicago 12, Ill.
Carroll Pressed Metal, Inc., 133 Dewey St., Worcester 10, Mass.
Cartwright, R. Tube Products Co., 609 St. Jean Ave., Detroit 14, Mich.
Carwin Co., Stiles Lane, North Haven, Conn.
Case, J. I. Co., 702 State St., Racine, Wis.
Caspers Tin Plate Co., 4100 W 42nd Pl., Chicago 32, Ill.
Cast Optics Corp., Room 8, 123 Newman St., Hackensack, N.J.
Castalloy Co., Inc., W Central St., Natick, Mass.
Casting Engineers, Inc., 2323 N Bosworth, Chicago, Ill.
Casting Engineers, 615 W. 131st St., New York 27, N.Y.
Casting Service Corp. of Michigan, Mathien Ave., Bridgman, Mich.

Castle, A. M. & Co., 3400 N Wolf Rd., Franklin Park, Ill.
Castle Rubber Co., P.O. Box 589, Butler, Pa.
Catalin Corp. of America, 1 Park Ave., New York 16, N.Y.
Cellcote Co., 4832 Ridge Rd., Cleveland 9, Ohio
Celanese Corp. of America, Celanese Polymer Co. Div. (Ad pp 224-225)
744 Broad St., Newark 2, N.J.
Celluplastic Corp., 24 Commerce St., Newark 5, N.J.
Cellusuede Products, Inc. (Ad p 348)
511 N Madison St., Rockford, Ill.
Celotex Corp., 120 S LaSalle St., Chicago 3, Ill.
Central Fabricators, Inc., 408 Poplar St., Cincinnati, Ohio
Central Felt & Fabrics Corp., 24 W 25th St., New York 10, N.Y.
Central Screw Co., 3501 S Shields, Chicago 9, Ill.
Central Screw Products Co., 284 Walker St., Detroit 7, Mich.
Central Steel & Wire Co., 3000 W 51st St., Chicago 32, Ill.
Centrifugal Casting Co., 3245 Cherry Ave., Long Beach 7, Calif.
Centrifugal Casting Co., 147 W 42nd St., New York 36, N.Y.
Centrifugal Casting Machine Co., P.O. Box 947, Tulsa 1, Okla.
Centr-O-Cast & Engineering Co., 45 South St. & St. Jean Ave., Detroit 14, Mich.
Century Die Casting Co., 2629 W Fletcher St., Chicago 18, Ill.
Ceromet, Inc., 16233 Gale Ave., La Puente, Calif.
Cerro Sales Corp., Sub. of Cerro Corp. (Ad p 154)
300 Park Ave., New York 22, N.Y.
Lewin-Mathes Div., 1111 Chouteau Ave., St. Louis 2, Mo.
Titan Metal Mfg. Co. Div., Bellefonte, Pa.
Chace, W.M. Co., 1600 Beard Ave., Detroit 9, Mich.
Chain Belt Co., 4701 W Greenfield Ave., Milwaukee 1, Wis.
Chambersburg Engineering Co., Derbyshire St., Chambersburg, Pa.
Champion Rivet Co., Harvard Ave. & E 108th St., Cleveland 5, Ohio
Chandler Products Corp., 1491 Chardon Rd., Cleveland 17, Ohio
Channel Master Corp., Ellenville, N.Y.
Chapman Machine Co., Inc., 41 Main St., Terryville, Conn.
Chardon Metal Products Co., Mill St., Chardon, Ohio
Chardon Rubber Co., 6th & Washington Aves., Chardon, Ohio
Charlotte Leather Belting Co., 209 E 12th St., Charlotte 1, N.C.
Char-Lynn Co., Diecasting Div., 2843 26th Ave. S, Minneapolis 6, Minn.
Chattanooga Aluminum Foundry, Inc., 2000 Chestnut St., Chattanooga 8, Tenn.
Chemetron Corp., Tube Turns Div., 224 E Broadway, Louisville 1, Ky.
Chemgineers, Inc., 4570 Brazil St., Los Angeles 39, Calif.
Chemical Corp. (Ad p 352)
67 Waltham Ave., Springfield 9, Mass.
Chemical Coatings Corp., Dividend Rd., Rocky Hill, Conn.
Chemical Coatings & Engineering Co., Inc., 221 Brooke St., Media, Pa.
Chemical Development Corp., Endicott St., Danvers, Mass.
Chemical Process Co., 1901 Spring St., Redwood City, Calif.
Chemical Products Corp. (Ad p 352)
King Philip Rd., East Providence 14, R.I.
Chemo Products, Inc., 100 Pulaski St., W. Warwick, R.I.
Chemore Corp., 2 Broadway, New York 4, N.Y.
Chemtrol, 404 W St. Anne Pl., Santa Ana, Calif.
Chemung Foundry Corp., Elmira, N.Y.
Chicago Aluminum Castings, 2647 Ogden Ave., Chicago, Ill.
Chicago Bridge & Iron Co., 332 S Michigan Ave., Chicago 4, Ill.
Chicago Development Corp., 5810 47th Ave., Riverdale, Md.
Chicago Extruded Metals Co., 1642 S 54th Ave., Cicero 9, Ill.
Chicago Gasket Co., 1271 W North Ave., Chicago 22, Ill.
Chicago Hardware Foundry Co., 2600 Commonwealth Ave., North Chicago, Ill.
Chicago Malleable Castings Co., 1225 W 120th St., Chicago 43, Ill.
Chicago Molded Products Corp., 1020 N Kolmar Ave., Chicago 35, Ill.
Campco Div., 2736 N Normandy Ave., Chicago 35, Ill.
Custom Molding Div., 1020 N Kolmar Ave., Chicago 51, Ill.
Chicago Powdered Metal Products Co., Schiller Park, Ill.
Chicago Rawhide Mfg. Co., 1301 Elston Ave., Chicago 22, Ill.
Chicago Rivet & Machine Co., 950 S 25th Ave., Bellwood, Ill.
Chicago Rubber Co., Inc., 653 Market St., Waukegan, Ill.
Chicago Smelting & Refining Corp., 3701 S Kedzie Ave., Chicago 32, Ill.
Chicago Steel Service Co., 4444 S Kildare Ave., Chicago 32, Ill.
Chicago Thrift-Etching Corp., 1555 N Sheffield Ave., Chicago 22, Ill.
Chicago White Metal Casting, Inc., 5239 W Grand Ave., Chicago 39, Ill.
Chicago-Allis Mfg. Corp., 113-125 N Green St., Chicago 7, Ill.
Chicopee Mills, Inc., 47 Worth St., New York 13, N.Y.
Lumite Div., 47 Worth St., New York 13, N.Y.
Chippewa Plastics Co., 1701 1st Ave., Chippewa Falls, Wis.
Chromalloy Corp., 450 Tarrytown Rd., White Plains, N.Y.
Elyria Foundry Div., Elyria, Ohio
Sintercast Div., 169 W Hwy., W. Nyack, N.Y.
Chromium Corp. of America, 100 Park Ave., New York 17, N.Y.
Chromizing Corp., 12536 Chadron Ave., Hawthorne, Calif.
Chrysler Corp., P.O. Box 1687, Detroit 31, Mich.
Amplex Div. (Ad p 395)
P.O. Box 2718, Detroit, 31, Mich.
Cycleweld Div., 5437 W Jefferson, Trenton, Mich.
Ciba Products Corp. (Ad pp 220-221)
Fairlawn, N.J.
Cincinnati Forging Co., 5604 Booster Pike, Cincinnati, Ohio
Cincinnati Industries Inc., 515 Station Ave., Cincinnati 15, Ohio
Clapp, E. D. Mfg. Co., Inc., 505 Genesee St., Auburn, N.Y.
Clark Bros. Bolt Co., Milldale, Conn.
Clark Perforating Co., 15875 Allen Rd., Milan, Mich.
Clarksville Foundry & Machine Works, Commerce & Spring Sts., Clarksville, Tenn.
Clayton & Lambert Mfg. Co., 1701 Dixie Hwy., Louisville 10, Ky.
Clayton Mark & Co., 1900 Dempster St., Evanston, Ill.
Clendenin Bros., Inc., 4309 Erdman Ave., Baltimore 13, Md.
Cleveland Cap Screw Co., 4444 Lee Rd., Cleveland 28, Ohio
Cleveland City Forge Co., 1621 Euclid Ave., Cleveland 15, Ohio
Cleveland Container Co., 6201 Barberton Ave., Cleveland 2, Ohio
Cleveland Electro Metals Co., 2391 W 38th St., Cleveland 13, Ohio
Cleveland Foundry & Mfg. Co., Inc., 685 6th St., NE, Cleveland, Tenn.
Cleveland Hard Facing Co., Inc., 3047 Stillson Ave., Cleveland 5, Ohio
Cleveland Metal Products Co., Washington & Center Sts., Cleveland 13, Ohio
Cleveland Porcelain Enameling Co., 3190 E 65th St., Cleveland 27, Ohio
Cleveland Powder Metal Co., Inc., 320 S Water St., Kent, Ohio
Cleveland Pressed Products Corp., 6712 Union Ave., Cleveland 5, Ohio
Cleveland Steel Specialty Co., 3765 E 91st St., Cleveland 5, Ohio
Cleveland Tungsten, Inc., 10200 Meech Ave., Cleveland 5, Ohio
Cleveland Wire Cloth & Mfg. Co., 3573 E 78th St., Cleveland 5, Ohio
Clevite Corp., Cleveland Graphite Bronze Div., 1700 St. Clair Ave., Cleveland 10, Ohio
Cliff Mfg. Co., 30240 Lakeland Blvd., Wickliffe, Ohio
Clifton Conduit Corp., 3300 Eastbourne Ave., Baltimore 24, Md.
Clinton Co., 1216 Elston Ave., Chicago 22, Ill.
Clinton Metal Products Co., 1076 W Locust St., Wilmington, Ohio
Clopay Corp., Clopay Sq., Cincinnati 14, Ohio
Closures, Inc., 46 State St., Waterbury, Conn.
Clover Industries, Inc., 578-588 Young St., Tonawanda, N.Y.
Cly-Del Mfg. Co., Inc., Box 1367, Waterbury, Conn.
Coast Mfg. & Supply Co., P.O. Box 71, Livermore, Calif.
Coast Metals, Inc., 201 Redneck Ave., Little Ferry, N.J.
Coast Pro-Seal & Mfg. Co., 2235 Beverly Blvd., Los Angeles 57, Calif.
Coated Abrasive Products, Inc., 30208 Lakeland Blvd., Wickliffe, Ohio
Coated Coil Corp., 513 W 30th St., New York 1, N.Y.
Coating Products, Inc., 101 W Forest Ave., Englewood, N.J.
Cochrane Foundry, Inc., Box 749, York, Pa.
Cohan Epner Co., Inc., 142 W 14th St., New York 11, N.Y.
Coil Anodizers, Inc., 1250 Keating Ave., Muskegon, Mich.
Cole-Roscoe Mfg. Co., 55 Bates Ct., South Norwalk, Conn.
Collis Co., Clinton, Iowa
Colonial Alloys Co., Ridge Ave. & Crawford St., Philadelphia 29, Pa.
Colonial Art Co., Inc., Crane Ave., Westfield, Mass.
Colonial Kolonite Co., 2232 Armitage Ave., Chicago 47, Ill.
Colonial Plastics Mfg. Co., 2685 E 79th St., Cleveland 4, Ohio
Colorado Fuel & Iron Corp., Continental Oil Bldg., Denver 2, Colo.
Pacific Coast Div., 1080 19th Ave., Oakland 6, Calif.
Roebling's, John A. Sons Div., 640 S Broad St., Trenton 2, N.J.
Wickwire Spencer Steel Div., 575 Madison Ave., New York 22, N.Y.
Colt's Plastics Co., Inc., P.O. Box 96, North Grosvenordale, Conn.
Columbia Metal Stamping Co., 11900 Harvard Ave., Cleveland 5, Ohio
Columbia Steel & Shafting Co., Summerill Tubing Co. Div., P.O. Box 1557, Pittsburgh 30, Pa.
Columbia Technical Corp., 24-30 Brooklyn-Queens Expressway West, Woodside 77, N.Y.
Columbia Tool Steel Co., Lincoln Hwy. & State St., Chicago Heights, Ill.
Columbian Bronze Corp., 216 N Main St., Freeport, N.Y.
Columbian Steel Tank Co., 1509 W 12th St., Kansas City 1, Mo.
Columbiana Pump Co., Columbiana, Ohio
Columbia-National Corp., 1 Gateway Center, Pittsburgh 22, Pa.
Columbus Bolt & Forging Co., 291 Marconi Blvd., Columbus 15, Ohio
Columbus Coated Fabrics Corp., 7th & Grant Aves., Columbus 16, Ohio
Columbus Dental Mfg. Co., 634 Wager St., Columbus 6, Ohio
Columbus Jack Corp., 1000 S Front St., Columbus 6, Ohio
Columbus Production Mfg. Co., 1559 McKinley, Columbia, Ohio
Combined Industries Co., P.O. Drawer 431, Catskill, N.Y.
Combustion Engineering, Inc., 1318 N Branch St., Chicago 22, Ill.
Comco Plastics, Inc., 98-32B Jamaica Ave., Richmond Hill, N.Y.
Comerford Mfg. Co., Inc., 81 Farmington Ave., Bristol, Conn.
Comet Metal Products Co., Inc., 91-04 132nd St., Richmond Hill 18, N.Y.
Commercial Chemical Co., 1021 Summer St., Cincinnati 4, Ohio
Commercial Iron Works, 2424 Porter, Los Angeles, Calif.
Commercial Plastics Co., 2810 W North Ave., Chicago 47, Ill.
Associated Plastic Div., 400 E Hines St., Midland, Mich.
Commercial Plastics & Supply Corp., 630 Broadway, New York 12, N.Y.
Commercial Screw Products Co., 15105 Darwin Ave., Cleveland 10, Ohio
Commercial Shearing & Stamping Co., 1775 Logan Ave., Youngstown, Ohio
Commercial Steel Casting Co., Cheney Ave., Marion, Ohio
Commercialores, Inc., Box 98, Clover, S.C.
Compacted Metals Corp., 99 Greenwood Ave., Waukegan, Ill.
Composite Forgings, Inc., 2300 W Jefferson Ave., Detroit 16, Mich.
Composite Industrial Metals, Inc., 235 Georgia Ave., Providence 5, R.I.
Compton Foundry, Compton, Calif.
Concord Mica Corp., 26 Crescent, Penacook, N.H.
Condamatic Co., Inc., 2700 E 9 Mile Rd., Hazel Park, Mich.
Conforming Matrix Corp. (Ad p 351)
12th & Woodruff Sts., Toledo 2, Ohio
Conn Perry Mfg. Co., 4341 Horatio Ave., Detroit 10, Mich.
Conneaut Die Casting Co., 618 Sandusky St., Conneaut, Ohio
Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn.
Connecticut Malleable Castings Co., New Haven 6, Conn.
Connecticut Mfg. Co., 115 Benedict St., Waterbury 20, Conn.
Connell Asbestos Mfg. Co., 117 Martense St., Brooklyn 26, N.Y.
Conner Mfg. Co., 828 S 17th St., Louisville, Ky.
Consolidated Foundries & Mfg. Corp., Michigan Steel Casting Co. Div., 1999 Guoin St., Detroit 7, Mich.
Consolidated Fruit Jar Co., 62 Water St., P.O. Box 109, New Brunswick, N.J.
Consolidated Industries, Inc., Milldale Rd., West Cheshire, Conn.
Consolidated Iron-Steel Mfg. Co., Ackerman Plastic Molding Div., 986 E 200th St., Cleveland 19, Ohio

In contacting suppliers, please mention the Materials Selector Issue

Consolidated Molded Products Corp., 1940 Thomas St., Scranton, Pa.
Consolidated Vacuum Corp., 1775 Mt. Read Blvd., Rochester 3, N.Y.
Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis.
Consoweld Corp., 700 Hooker St., Wisconsin Rapids, Wis.
Continental Boiler & Sheet Iron Works, 5603 W Park Ave., St. Louis, Mo.
Continental Can Co., 100 E 42nd St., New York 17, N.Y.
Conolite Div., 205 W 14th St., Wilmington, Del.
Flexible Packaging Div., Mount Vernon, Ohio
Continental Coatings Corp., 17706 Miles Ave., Cleveland, Ohio
Continental Copper & Steel Industries, Inc., 345 Madison Ave., New York 17, N.Y.
Niagara Falls Smelting & Refining Div., 2200-2214 Elmwood Ave., Buffalo 23, N.Y.
Continental Die Casting Corp., 9615 Grinnell Ave., Detroit 13, Mich.
Continental Felt Co. (Ad p 318)
26 W 15th St., New York 11, N.Y.
Continental Gin Co., Birmingham, Ala.
Continental Rubber Works, 1985 Liberty St., Erie 6, Pa.
Continental Screw Co., 459 Mt. Pleasant St., New Bedford, Mass.
Continental Steel Corp., 1109 S Main St., Kokomo, Ind.
Continental Wire & Iron Works, Continental Nu-Steel Metal Products Div., 1249 S Ashland Ave., Chicago 8, Ill.
Continental-Diamond Fibre Corp., Newark, Del.
Continental-Emsco Co., P.O. Box 2098, Terminal Annex, Los Angeles 54, Calif.
Contour Extrusion Co., 517 Fayette Ave., Mamaroneck, N.Y.
Control Parts Corp., 530 Burnside Ave., Inwood 96, L.I., N.Y.
Conversion Chemical Corp. (Ad p 348)
98 E Main St., Rockville, Conn.
Cooley, W.J. & Co., P.O. Box 1471, 107 Hernando, Memphis, Tenn.
Cooper Alloy Corp., Bloy St. & Ramsey Ave., Hillside 5, N.J.
Cooper, Peter Corp., Palmer St., Gowanda, N.Y.
Cooper-Bessemer Corp., Mt. Vernon, Ohio
Coors Porcelain Co., 600 9th St., Golden, Colo.
Co-Polymer Chemicals Inc., 12350 Merriman Rd., Livonia, Mich.
Copolymer Rubber and Chemical Corp., P.O. Box 2591, Baton Rouge 1, La.
Copper and Brass Sales, Inc., 6555 E Davison St., Detroit 12, Mich.
Copper Range Co., Hussey, C.G. & Co. Div. (Ad p 160)
2850 2nd Ave., Pittsburgh 19, Pa.
Copperweld Steel Co., Warren, Ohio
Aristoloy Steel Div., Mahoning Ave. Ext., Warren, Ohio
Ohio Seamless Tube Div., Shelby, Ohio
Superior Steel Div., Superior St., Carnegie, Pa.
Cordo Chemical Corp., 34 Smith St., Norwalk, Conn.
Cordo Molding Products, Inc., 34 Smith St., Norwalk, Conn.
Corite Products, Inc., 6553 W George St., Chicago 34, Ill.
Cornell and Underhill, Inc., 1310 Jefferson St., Hoboken, N.J.
Corning Glass Works (Ad p 321)
Corning, N. Y.
Corson Industries, 1228 Belmont Ave., Philadelphia 4, Pa.
Cosden Paint Co., Cherry St. & Lee Ave., Beverly, N.J.
Cosmo Plastics Co., 3239 W 14th St., Cleveland 9, Ohio
Cowles Chemical Co., 7016 Euclid Ave., Cleveland 3, Ohio
Coyne & Paddock, Inc., 40-09 21st St., Long Island City 1, N.Y.
Craft Mfg. Co., 2301 Davis St., North Chicago, Ill.
Craft Metal Spinning Co., 302 E Main St., Dundee, Ill.
Craftint Mfg. Co., 18501 Euclid Ave., Cleveland 12, Ohio
Crane Co., 836 S Michigan Ave., Chicago 5, Ill.
Crane Packing Co., 6400 Oakton St., Morton Grove, Ill.
Crane Plastics, Inc. (Ad p 430)
2141 Fairwood Ave., Columbus, Ohio
Crawford & Doherty Foundry Co., 4604 SE 17th Ave., Portland, Ore.
Crescent Bronze Powder Co., 116 W Illinois St., Chicago 10, Ill.
Crescent Co., Inc., Carol Cable Co. Div., 90 Middle St., Pawtucket, R.I.
Crescent Plastics, Inc., 955 Diamond Ave., Evansville 7, Ind.
Crest Chemical Industries Corp., 132-34 32nd Ave., Flushing, N.Y.
Crobalt, Inc., 2800 S State St., Ann Arbor, Mich.
Croname, Inc., 6275 Howard St., Chicago 48, Ill.
Crosby Co., 183 Pratt St., Buffalo 4, N.Y.
Crown Metal Co., 121 E Washington St., Milwaukee 4, Wis.
Crown Non-Ferrous Foundry, Inc. Concord Ave., Chester, Pa.
Crucible Steel Co. of America (Ad p 89)
P.O. Box 2518, Pittsburgh 30, Pa.
Titanium and Vacuum Metal Products Div., P.O. Box 2518, Pittsburgh 30, Pa.
Crucible Steel Casting Co., Union Ave. & Penn R.R., Lansdowne, Pa.
Cruver Mfg. Co., 2460 W Jackson, Chicago 12, Ill.
CrystalX Corp., W Lenni Rd., Lenni Mills, Pa.
Cumberland Steel Co., 101 Williams St., Cumberland, Md.
Curbell, Inc., 777 Hertel Ave., Buffalo 7, N.Y.
Curtis Cos., Inc., New London, Wis.
Curtis Products Co., 7 Cherry Ave., Waterbury 4, Conn.
Curtis Screw Co., Inc., 19 Gail St., Buffalo 13, N.Y.
Curtiss-Wright Corp., 304 Valley Blvd., Wood-Ridge, N.J.
Metals Processing Div., 706 Northland Ave., Buffalo 15, N.Y.
Plastics Div., 50 Rockefeller Plaza, New York, N.Y.
Utica Div., 50500 Mound Rd., Utica, Mich.
Custom Tool and Mfg. Co., 2201 N 2nd St., Minneapolis 11, Minn.
Cuyahoga Stamping Co., 10201 Harvard Ave., Cleveland 5, Ohio
Cyril Bath Co., 32342 Aurora Rd., Solon, Ohio

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DK Mfg. Co., Cobra Metal Hose Div., 5059 S Kedzie Ave., Chicago 32, Ill.
Dacar Chemical Products Co., 1007 McCartney St., Pittsburgh, Pa.
Dahlin, C. A. Co., 2727 Clybourn Ave., Chicago 14, Ill.
Dalton Foundries, Inc., Lincoln & Jefferson Sts., Warsaw, Ind.
Damascus Tube Co., P.O. Box 71, Greenville, Pa.
Dana Corp., Bennett Rd. & Sylvania Ave., Toledo 1, Ohio
Auburn Div., Auburn, Ind.
Parish Pressed Steel Div., Box 1422, Reading, Pa.
Danby Mfg. Co., Portland, Mich.
Danielson Mfg. Co., Lee St., Danielson, Conn.
Dapol Plastics, Inc., 53 Northboro St., Worcester 4, Mass.
Darby Corp., 1st & Walker Sts., Kansas City 15, Kan.
Dare Products, Inc., 860 Betterly Rd., Battle Creek, Mich.
Darling, L. A., Midwest Foundry Co. Div., 66-76 Clark St., Coldwater, Mich.
Darling Valve & Mfg. Co., Walnut & Marshall Sts., Williamsport, Pa.
Darlington Veneer Co., 4th St., Darlington, S.C.
Daubert Chemical Co., 4700 S Central Ave., Chicago 38, Ill.
Davidson Rubber Co., 50 Brighton St., Charlestown 29, Mass.
Davis & Hemphill, 2000 Furnace Ave., Elkridge 27, Md.
Davis, Joseph Plastics Co., Kearny, N.J.
Davis Products Corp., 30 Main St., Brooklyn 1, N.Y.
Dawlen Corp., 1911 Fargo Rd., Jackson, Mich.
Day Co., 810 3rd Ave., NE, Minneapolis 13, Minn.
Dayco Corp., 2345 Riverview West, Dayton 1, Ohio
Day, James B. & Co., 1872 Clybourn Ave., Chicago 14, Ill.
Dayton Bronze Bearing Co., 111 Front St., Dayton 2, Ohio
Dayton Foundry, 11803 Industrial Ave., Hollydale, Calif.
Dayton Malleable Iron Co., P.O. Box 980, Dayton 1, Ohio
G. H. R. Div., 400 Detrick St., Dayton 1, Ohio
Ironton Malleable Div., Ironton, Ohio
Meta-Mold Aluminum Co., 525 E Hamilton Rd., Cedarburg, Wis.
Ohio Malleable Div., Box 88, Sta. A, Columbus, Ohio
Pratt & Letchworth Div., 189 Tonawanda St., Buffalo 7, N.Y.
Dayton Rogers Mfg. Co., 2824 13th Ave., S, Minneapolis 7, Minn.
Dayton Steel Foundry Co., 1366 Miami Chapel Rd., Dayton 1, Ohio
Dearborn Stamping Co., 10501 Haggerty Ave., Dearborn, Mich.
Debevoise Co., 74 20th St., Brooklyn 32, N.Y.
Decatur Automatic Co., P.O. Box 26, Warrensburg, Ill.
Decatur Casting Co., 822 Dayton Ave., Decatur, Ind.
Decrow Engineering Corp., Main St., Middleport, N.Y.
Deerfield Mfg. Co., 4th Ave., Mason, Ohio
Defiance Metal Products Co., 21 Seneca St., Defiance, Ohio
Defiance Stamping Co., Perry & German Sts., Defiance, Ohio
De Laval Steam Turbine Co., 853 Nottingham Way, Trenton 2, N.J.
Delaware Tool Steel Corp., 34th & Market Sts., Wilmington, Del.
Delo Screw Products Co., 38 S Franklin St., Delaware, Ohio
Delron Co., Inc., 5224 Southern Ave., South Gate, Calif.
Delta Plastics Co., 776 Creek Rd., Bellmawr, N.J.
Delta Plywood Corp., Cotton Plant, Ark.
Dennis Chemical Co., 2701 Papin St., St. Louis 3, Mo.
Denver Plastics, Inc., 15200 W Colfax Ave., Golden, Colo.
Dependable Automatic Screw Co., 282 S Leonard St., Waterbury 20, Conn.
Derby Castings Co., 593 N Main St., Seymour, Conn.
Deringer Metallurgical Corp., 8131 Monticello Ave., Skokie, Ill.
De Sanno Foundry & Machine Co., 1919 Peralta St., Oakland 7, Calif.
Designers Metal Corp., 469 E 159th St., Harvey, Ill.
De Soto Chemical Coatings, Inc., 1350 S Kostner Ave., Chicago 23, Ill.
De Soto Paint & Varnish Co., P.O. Box 186, Garland, Tex.
Detrex Chemical Industries, Inc., Box 501, R P K Annex 32, Detroit, Mich.
Detroit Brass & Malleable Co., 2960 7th St., Wyandotte, Mich.
Detroit Float & Stamping Co., 625 Monroe St., Detroit, Mich.
Detroit Gasket & Mfg. Co., Extruded Metals Div., 12640 Burt Rd., Detroit 23, Mich.
Detroit Macoid Corp., 12340 Cloverdale, Detroit 4, Mich.
Detroit Stamping Co., 350 Midland St., Detroit 3, Mich.
Detroit Steel Corp., Portsmouth Div., Detroit 9, Mich.
Deuscher, H.P. Co., 7th & Hanover Sts., Hamilton, Ohio
Devcon Corp., Danvers, Mass.
Devoe & Raynolds Co., Inc., Jones-Dabney Co. Div., 1481 S 11th St., Louisville 8, Ky.
Dewitt Plastics, Aurelius Ave., Auburn, N.Y.
Dexter, C.H. & Sons, Inc., Windsor Locks, Conn.
Diamond Alkali Co., 300 Union Commerce Bldg., Cleveland 14, Ohio
Diamond Lumber Co., 323 Pittock Block, Portland 5, Ore.
Diamond Mfg. Co., W 8th St., Wyoming, Pa.
Diamonite Products Mfg. Co., Shreve, Ohio
Die Cast Products, Inc., 621 W Rosecrans Ave., Gardena, Calif.
Diecast Corp., 522-524 Happ Ave., Jackson, Mich.
Dietzel Lead Burning Co., Narrows Run Rd., Coraopolis, Pa.
Dimco-Gray Co., 207 E 6th St., Dayton 2, Ohio
Dip Seal Plastics, Inc., 2311 23rd Ave., Rockford, Ill.
Dirilyte Co. of America, Inc., 1142 S Main St., Kokomo, Ind.
Disogrin Industries, 510 S Fulton Ave., Mount Vernon, N.Y.
Diversey Corp., Metal Industries Div., 1820 Roscoe St., Chicago 13, Ill.
Division Lead Co., 7742 W 61st Pl., Summit, Ill.
Dixie Aluminum Corp., 304 E 2nd Ave., Rome, Ga.
Dixie Bronze Co., P.O. Box 1146, Birmingham 1, Ala.
Dixie Galvanizing & Tank Co., 1901 McQuade St., Jacksonville, Fla.
Dixie Lead Co., Sargent Rd., Box 8625, Dallas 16, Tex.
Dixie Plastics Mfg. Co., 3017 N Galvez St., New Orleans, La.
Dixon Corp., Burnside St., Bristol, R.I.
Dixon, Joseph Crucible Co., Jersey City 3, N.J.
Dixon Sintaloy, Inc., 535 Hope St., Stamford, Conn.
Dodge Fibers Corp., John St., Hoosick Falls, N.Y.
Dodge Mfg. Corp., 500 S Union St., Mishawaka, Ind.
Dodge Steel Co., 6501 State Rd., Philadelphia 35, Pa.
Dolin Metal Products, Inc., 315 Lexington Ave., Brooklyn 16, N.Y.
Dollin Corp., 650 S 21st St., Irvington 11, N.J.
Donegal Steel Foundry Co., 681 E Market St., Marietta, Pa.
Donovan, F. C. Inc., 192 South St., Boston, Mass.
Dore, John L., Inc., 5602 Schuler St., Houston 7, Tex.
Dormont Mfg. Co., 5607 Butler St., Pittsburgh 1, Pa.
Dostal Foundry & Machine Co., Box 180, Pontiac, Mich.

Douglas Aircraft Co., Inc., Aircomb Div., 1720 Pico Blvd., Santa Monica Calif.
Douglas & Sturgess, 563 7th St., San Francisco 3, Calif.
Dow Chemical Co., Midland, Mich.
  Dobeckman Co. Div., 3301 Monroe Ave., Cleveland 13, Ohio
  Plastics Div. (Ad pp 249-256)
  Midland, Mich.
Dow Corning Corp., Midland, Mich.
Downington Iron Works, 161 Wallace St., Downington, Pa.
Dravo Corp., 102 5th Ave., Pittsburgh 22, Pa.
Brown Metal Tube Co., 101 Elm St., Thomaston, Conn.
Dresser Industries, Inc., Dresser Mfg. Div., 43 Fisher Ave., Bradford, Pa.
Dresser Operations, Inc., Clark Bros. Co. Div., Lincoln Ave. & 5th St., Olean, N.Y.
Drexel Screw Products Co., 6200 S Oakley Ave., Chicago 36, Ill.
Driver, Wilbur B. Co., 1875 McCarter Hwy., Newark 4, N.J.
  Western Gold & Platinum Co. Sub., 525 Harbor Blvd., Belmont, Calif.
Driver-Harris Co., 201 Middlesex St., Harrison, N.J.
Drie-Lok Sales Corp, 777 Park Ave., Sycamore, Ill.
Dumm Specialties, Ltd., 2 Johnson St., Newark 5, N.J.
Du-Co Ceramics Co., Box 278, Saxonburg, Pa.
Ductile Iron Foundry, Inc., Honeyspot Rd. Extension, Stratford, Conn.
Dudek & Bock Spring Mfg. Co., 4014 W Grand Ave., Chicago 51, Ill.
Duffin Mfg. Co., 2307 Leavitt Rd., Lorain, Ohio
Du-Lite Chemical Corp., Middletown, Conn.
Duluth Brass Works Co., 5002 Ramsey St., Duluth 7, Minn.
Dumont Corp., 607 Irwin St., San Rafael, Calif.
Dunlop Tire & Rubber Corp., Buffalo 5, N.Y.
Duralcan Assoc., 352 Plymouth Rd., Union, N.J.
Duplex Mfg. Corp., P.O. Box 418, Fort Smith, Ark.
Duplican Co., Inc., 1221 Turnpike Rd., Westboro, Mass.
du Pont de Nemours, E. I. & Co., Inc. (Ad pp 217, 247-248)
  Wilmington 98, Del.
Duracote Corp., 350 N Diamond St., Ravenna, Ohio
Dura Plastics of New York, Inc., 303 5th Ave., New York 16, N.Y.
Durable Formed Products, Inc., 74 Varick St., New York 13, N.Y.
Durable Rubber Products Co., 609 W Lake St., Chicago 6, Ill.
Duralac Chemical Corp., 84 Lister Ave., Newark 5, N.J.
Dura-Lee Corp., 1102 S Mill, Kansas City, Kan.
Duraloy Co. (Ad p 420)
  Bridge St., Scottdale, Pa.
Durel, Inc., 1098 Jackson St., Dubuque, Iowa
Durethene Corp., 1859 S 55th Ave., Chicago 50, Ill.
Durion Co., Inc., 450 N Findlay St., Dayton, Ohio
  Modern Industrial Plastics Div., Box 1019, Dayton 1, Ohio
Duro Screw & Mfg. Co., 1064 Springfield Rd., Union, N.J.
Du-Wel Metal Products, Inc., P.O. Box 307, Bangor, Mich.
Dyna-Therm Chemical Corp., 3813 Hoke Ave., Culver City, Calif.
  Plas-Kem Corp. Div., 100 W Alameda St., Burbank, Calif.

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Eagle-Picher Co., American Bldg., Cincinnati 1, Ohio
  Chicago Vitreous Corp. Div., 1425 S 55th Ct., Cicero 50, Ill.
  Fabricon Products Div., 1721 W Pleasant Ave., River Rouge 18, Mich.
Earl Paint Corp., 240 Genesee St., Utica 2, N.Y.
Earley, Sam C. Corp., 3230 Monroe St., Toledo 6, Ohio
East Birmingham Bronze Foundry Co., 831 N 36th Way, Birmingham 4, Ala.
Eastern Brass & Copper Co., 1122 E 180th St., New York 60, N.Y.
Eastern Machine Screw Corp., Truman & Barclay Sts., New Haven 6, Conn
Eastern Malleable Iron Co., P.O. Box 349, Wilmington 99, Del.
Eastern Rolling Mills, Inc., 1122 E 180th St., New York 60, N.Y.
Eastern Smelting & Refining Corp., 109 W Brookline St., Boston 18, Mass.
Eastern Stainless Steel Corp., P.O. Box 1975, Baltimore 3, Md.
Eastern Tool & Mfg. Co., 1 Montgomery St., Belleville 9, N.J.
Eastern Tool & Stamping Co., Inc., 110 Ballard St., Saugus, Mass.
Eastman Kodak Co., 343 State St., Rochester 4, N.Y.
  Eastman Chemical Products, Inc. Sub. (Ad p 494)
  260 Madison Ave., New York 16, N.Y.
  Texas Eastman Co. Div., Longview, Tex.
Easton Plastic Products Co., Inc., 900 Line St., Easton, Pa.
Eaton Mfg. Co., 9711 French Rd., Detroit, Mich.
  Foundry Div. (Ad p 405)
  700 E Huron, Vassar, Mich.
  Powdered Metals Div., 325 Jay St., Coldwater, Mich.
  Reliance Div., 25 Charles Ave., Massillon, Ohio
Eberhart Steel Products, Powdered Metals Div., 317 E Jefferson Blvd., Mishawaka, Ind.
Eby, Hugh H. Co., 4701 Germantown Ave., Philadelphia 20, Pa.
Eclipse Plastic Industries, Inc., Box 430, Sarasota, Fla.
Economy Machine Products Co., 5214 W Lawrence Ave., Chicago 30, Ill.
Edgar Plastic Kaolin Co., Materdyne Ave., Edgar, Fla.
Edgcomb Steel & Aluminum Corp., Hillside Ave., N.J.
Edgewater Steel Co., Box 478, Pittsburgh, Pa.
Edna Lite Optical Co., Inc., 200 N Water St., Peekskill, N.Y.
Egan & Hausman Co., Inc., 9-02 43rd Rd., Long Island City 1, N.Y.
Egyptian Lacquer Mfg. Co., P.O. Box 444, Newark 1, N.J.
Ehrsam, J. B. & Sons Mfg. Co., Enterprise, Kan.
Elmco Corp., American Foundry & Machine Div., P.O. Box 300, Salt Lake City 10, Utah
Ekstrand & Tholand, 420 Lexington Ave., New York 17, N.Y.
Elastic Stop Nut Corp. of America, 2330 Vauxhall Rd., Union, N.J.
Elastomer Chemical Corp., 212 Wright St., Newark 7, N.J.
Elchinger, Charles F., 916 Magazine St., New Orleans 12, La.
Elco Tool and Screw Corp., 1800 Broadway, Rockford, Ill.
Electric Autolite Co., Champlain & Mulberry Sts., Toledo 1, Ohio
  Ceramic Div., Fostoria, Ohio
  Woodstock Div., 501 Clay St., Woodstock, Ill.
Electric Materials Co., Clay & Washington Sts., North East, Pa.
Electric Steel Castings Co., 1045 Main St. Speedway, Indianapolis 24, Ind.
Electric Storage Battery Co., Stokes Molded Products Div., Taylor St. & Webster, Trenton 4, N.J.
  Jessall Plastics Div., 889 Farmington Ave., Kensington, Conn.
Electrical Refractories Co., East Palestine, Ohio
Electro Chemical Engineering & Mfg. Co., 750 Broad St., Emmaus, Pa.
Electro Refractories & Abrasives Corp., Willett Rd., Lackawanna 18, N.Y.
Electrocast Steel Foundry Co., 4701 W 15th Pl., Cicero 50, Ill.
Electro-Ceramics, Inc., 2645 S & W St., Salt Lake City, Utah
Electro-Chemical Engineering Co., 1100 Brook Ave., New York 56, N.Y.
Electrofilm, Inc., 7116 Laurel Canyon Blvd., North Hollywood, Calif.
Electrolizing Co., 1505 East End Ave., Chicago Heights, Ill.
Electron Corp., 651 Rio Grande Ave., Littleton, Colo.
Electronic Mechanics, Inc., 101 Clifton Blvd., Clifton, N.J.
Electronic Parts Mfg. Co., Inc., 508 25th St., Union City, N.J.
Electronic Production & Development, Inc., Chemical Div., 501 N Prairie Ave., Hawthorne, Calif.
Elgin National Watch Co., 107 National St., Elgin, Ill.
Eljay Corp., 2900 Herbert St., Baltimore 16, Md.
Elk Engineering Works, Inc., 220 Stackpole St., St. Marys, Pa.
Elkhart Foundry & Machine Co., Inc., 220-330 S Elkhart Ave., Elkhart, Ind.
Elkhart Iron Works, 1217-33 Broad St., St. Joseph, Mich.
Ellicott-Brandt, Inc., 1700 Ridgely St., Baltimore 30, Md.
Elliott Bros. Steel Co., 902-914 N Cedar St., New Castle, Pa.
Ellwood City Iron & Wire Co., 416 Pittsburgh Circle, Ellwood City, Pa.
Elm Coated Fabrics Co., Inc., 261 5th Ave., New York 16, N.Y.
Elsby, J.S. Inc., 3223 W Burnham St., Milwaukee 15, Wis.
Emerson & Cuming, Inc., 869 Washington St., Canton, Mass.
Emerson-Sack-Warner Corp., 85 Washington St., Somerville, Mass.
Emery, George D. Co., 220 11th Ave., New York, N.Y.
Emmaus Foundry & Machine Co., 4th & Furnace Sts., Emmaus, Pa.
Empire Foundry Co., Inc., 429 3rd St., Oakland 7, Calif.
Empire Metal Co., 820 E Water St., Syracuse 3, N.Y.
Empire Pattern and Foundry Co., P.O. Box 1647, Tulsa 1, Okla.
Empire Spring Co., 210 S Abbe Rd., Elyria, Ohio
Empire Steel Castings, Inc., P.O. Box 139, Reading, Pa.
Enamel Products Co., 341 Eddy Rd., Cleveland 8, Ohio
Endicott Forging & Mfg. Co., Inc., 1901 North St., Endicott, N.Y.
Enflo Corp., Fellowship Rd. & Rt. #73, Maple Shade, N.J.
Engelhard Industries, Inc., 904 Passaic Ave., East Newark, N.J.
  American Platinum & Silver Div., 231 New Jersey R.R. Ave., Newark 5, N.J.
  Amersil Quartz Div., 685 Ramsey Ave., Hillside, N.J.
  Baker Platinum Div., 113 Astor St., Newark, N.J.
  Makepeace, D.E. Div., Pine & Durham Sts., Attleboro, Mass.
  Wilson, H. A. Div., 2655 U.S. Rte. 22, Union, N.J.
Engineered Ceramics Mfg. Co., 1435 W Fulton St., Chicago 7, Ill.
Engineered Plastics, Inc., American Sinterings Div., P.O. Drawer P, Watertown, Conn.
Engineered Precision Casting Co., Highway 79, P.O. Box 68, Matawan, N.J.
Engineering Products & Specialties, Inc., Dunnel Lane, Pawtucket, R.I.
Englander Co., Inc., Industrial Products Div., 227 N. Warwick Ave., Baltimore 23, Md.
Enoch Mfg. Co., P.O. Box 5201, Portland 16, Ore.
Enterprise Galvanizing Co., 2507 E Cumberland St., Philadelphia 25, Pa.
Enterprise Wheel & Car Corp., P.O. Box 151, Bristol, Va.
Enthone, Inc. (Ad p 346)
  442 Elm St., New Haven 8, Conn.
Erdle Perforating Co., Inc., 171 York St., Rochester 11, N.Y.
Erie Bolt & Nut Co., 1325 Liberty St., Erie, Pa.
Erie Bronze Co., 19th & Chestnut Sts., Erie, Pa.
Erie Casting Co., 1534 German St., Erie, Pa.
Erie Ceramic Arts Co., 3120 W 22nd St., Erie, Pa.
Erie Enameling Co., 1400 W 20th St., Erie 4, Pa.
Erie Malleable Iron Co., 680 W 12th St., Erie, Pa
Erie Resistor Corp., Plastics Div., 644 W 12th St., Erie, Pa.
Erie Scientific Corp., 693 Seneca St., Buffalo 10, N.Y.
Erskine Precision Wire Corp., 210 S Broad St., Emporium, Pa.
Ervite Corp., 4000 W Ridge Rd., Erie, Pa.
Escambia Chemical Corp., 261 Madison Ave., New York 16, N.Y.
Esco Corp., 2141 NW 25th Ave., Portland 10, Ore.
Essential Bar Products Co., 2526 Brooklyn Road, Jackson, Mich.
Essex Wire Corp., 1601 Wall St., Fort Wayne, Ind.
  Carolina Industrial Plastics Div., Mount Airy, N.C.
  Essex Industrial Products Div., 2601 S Adams, Marion, Ind.
  Magnet Wire Div., 1601 Wall St., Fort Wayne, Ind.
Est Co., Inc., Grafton, Wis.
Ethylene Chemical Corp., 245 Broad St., Summit, N.J.
Eureka Electric Products Inc., Clay St., North East, Pa.
Eutectic Welding Alloys Corp., 40-40 172nd St., Flushing 58, N.Y.
Evans, George Corp., 121 37th St., Moline, Ill.
Evans Metal Co., 740 Lambert Dr. NE, Atlanta 5, Ga.
Evans Products Co., Hardboard Div., P.O. Box 651, Corvallis, Ore.
  Haskelite Mfg. Div., 701 Ann St., NW, Grand Rapids, Mich.
Everard Tap & Die Corp., 215 E 144th St., New York 51, N.Y.
Everlite Corp., 1218 E Cherry St., Seattle 22, Wash.
Exalco Mfg. Co., 46 Sheldon Rd., Berea, Ohio
Excelsior Leather Washer Mfg. Co., Inc., 720 Chestnut St., Rockford, Ill.
Exeter Mfg. Co., 1451 Broadway, New York 36, N.Y.
Exmet Corp., 127 Marbledale Rd., Tuckahoe, N.Y.
Extruders, Inc., 3232 W El Segundo Blvd., Hawthorne, Calif.
Eynon-Dakin Co., 9900 Freeland Ave., Detroit 27, Mich.

In contacting suppliers, please mention the Materials Selector Issue

f

Fabriform Metal Brazing, 7720 Male Ave., Los Angeles 1, Calif.
Fabristeel Products, Inc., 21500 W 8 Mile Rd., Detroit 41, Mich.
Fahralloy Co., 149th St. & Loomis St., Harvey, Ill.
Fairbanks, Morse & Co., Beloit, Wis.
Fairchild Screw Products, Inc., White St., Winsted, Conn.
Fairfield Aluminum Castings Co., 603 N 8th St., Fairfield, Iowa
Fairmont Aluminum Co. (Ad p 151)
Fairmont, W.Va.
Falcon Foundry Co. (Ad p 154)
Lowellville, Ohio
Falge Engineering Corp., 4733 Elm St., Bethesda 14, Md.
Falk Corp., Box 492, Milwaukee 1, Wis.
Falls Machine Co., 1625 Massillon Rd., Akron 12, Ohio
Falstrom Co., 70 Falstrom Ct., Passaic, N.J.
Famco, Inc., 6200 Strawberry Lane, Louisville 9, Ky.
Fanner Mfg. Co., Brookside Park, Cleveland 9, Ohio
Murray Products Div., 12400 Crossburn Ave., Cleveland 11, Ohio
Fansteel Metallurgical Corp. (Ad pp 161-164)
North Chicago, Ill.
F. A. Pilgrim Co., 4449 Lake Park Rd., Youngstown 12, Ohio
Farnam Mfg. Co., 2000 Sweeten Creek Rd., Asheville, N.C.
Farrel-Birmingham Co., Inc., 25 Main St., Ansonia, Conn.
Farrelloy Co., 1243-45 N 26th St., Philadelphia 21, Pa.
Farwell Metal Fabricating, 77 W Fairfield Ave., St. Paul 7, Minn.
Faultless Rubber Co., Ashland, Ohio
Fearon Foundry Co., 1420 W Kinzie St., Chicago 22, Ill.
Federal Die Casting Co., 2226 N Elston, Chicago, Ill.
Federal Machine and Welder Co., 1745 Overland Ave. NE, Warren, Ohio
Federal Malleable Co., 805 S 72nd St., Milwaukee, Wis.
Federal Screw Works, Congdon St., Chelsea, Mich.
Federal Steel Products Corp., 415 N St. Charles St., Houston 3, Tex.
Federal Tool Corp., 3600 W Pratt Blvd., Chicago 45, Ill.
Federal Tool Mfg. Co., 3600 Alabama Ave., Minneapolis 16, Minn.
Felsenthal, G. & Sons, 3500 N Kedzie, Chicago 18, Ill.
Felt Products Mfg. Co., 7450 N McCormick Blvd., Skokie, Ill.
Felters Co. (Ad p 302)
220 South St., Boston 11, Mass.
Femco Mfg. Co., Inc., 22845 Hoover Rd., Detroit 5, Mich.
Fenestra, Inc., 2250 E Grand Blvd., Detroit 11, Mich.
Ferro Corp., 4150 E 56th St., Cleveland 5, Ohio
Fiber Glass Div., Fiber Glass Rd., Nashville 11, Tenn.
Louthan Mfg. Co. Div. P.O. Box 781, East Liverpool, Ohio
Ferro Enameling Co., 1100 57th Ave., Oakland 21, Calif.
Ferro Powdered Metals, Inc., Box 312, Salem, Ind.
Ferro-Co Corp., Schori Process Div., 8-11 43rd Rd., Long Island City 1, N.Y.
Ferroxcube Corp. of America, E Bridge St., Saugerties, N.Y.
Fiber Glass Industries, Inc., Amsterdam, N.Y.
Fiberfil, Inc., Fox Farm Road, Warsaw, Ind.
Fiberglass Ohio Inc., 9603 Clinton Rd., Cleveland 9, Ohio
Fiberite Corp., 516 W 4th, Winona, Minn.
Fibron Products, Inc., 500 Fibron Bldg., 45 Mechanic St., Buffalo 2, N.Y.
Fidelity Chemical Products Corp., 470 Frelinghuysen Ave., Newark 12, N.J.
Fidelity Felt & Mfg. Co., 22 W 15th St., New York 11, N.Y.
Figley Die & Stamping Co., 401 Agnes St., Defiance, Ohio
Filon Plastics Corp., 333 N Van Ness Ave., Hawthorne, Calif.
Filpaco Industries, Inc., 2426 S Michigan Ave., Chicago 16, Ill.
Fine Organics, Inc., 205 Main St., Lodi, N.J.
Finkl, A. & Sons Co., 2011 Southport Ave., Chicago 14, Ill.
Firestone Plastics Co., P.O. Box 690, Pottstown, Pa.
Firestone Tire & Rubber Co., 1200 Firestone Pkwy., Akron 17, Ohio
Firestone Rubber & Latex Products Co. Div., 1 Firestone Ave., Fall River, Mass.
Firestone Steel Products Co. Div., Akron 17, Ohio
World Bestos Div., 1112 S 25th St., New Castle, Ind.
Xylos Div., Akron 17, Ohio
Firmaline Products of Crompton & Knowles, 7 Pierce Ave., Midland Park, N.J.
Firth Sterling, Inc., 3113 Forbes Ave., Pittsburgh, Pa.
Fischer Casting Co., Inc., P.O. Box M, Dunellen, N.J.
Fischer & Porter Co., 510 Jacksonville Rd., Warminster, Pa.
Warminster Fiberglass Co. Div., County Line & Warminster Rd., Warminster, Pa.
Fischer Special Mfg. Co., 450 Morgan St., Cincinnati 20, Ohio
Fish-Schurman Corp., 70 Portman Rd., New Rochelle, N.Y.
Fitchburg Foundry, Inc., Benson St., Fitchburg, Mass.
Fitzgibbons Boiler Co., Inc., Oswego, N.Y.
FitzSimons Mfg. Co., 3775 E Outer Drive, Detroit 34, Mich.
Fletcher Enamel Co., P.O. Box 67, Dunbar, W. Va.
Flexfirm Products, 2300 N Chico Ave., El Monte, Calif.
Flexible Tubing Corp., Guilford, Conn.
Flexonics Corp., 1315 S 3rd Ave., Maywood, Ill.
Flexrock Co., 36th & Filbert Sts., Philadelphia 1, Pa.
Fluoro-Plastics Inc. Div., 36th & Filbert Sts., Philadelphia 1, Pa.
Flood City Brass & Electric Co., Messenger & Elder Sts., Johnstown, Pa.
Florence Pipe Foundry & Machine Co., Front St., Florence, N.J.
Florin Foundry & Mfg. Co., Florin, Pa.
Fluorocarbon Co., 1754 S Clementine St., Anaheim, Calif.
Flynn & Emrich Co., 301 Holliday St., Baltimore 2, Md.
Flynn, Michael Mfg. Co., 700 E Godfrey Ave., Philadelphia 24, Pa.
Foam Products, Inc., P.O. Box 27, Manchester, Pa.
Foamade Industries, 14851 W 11 Mile Rd., Oak Park 37, Mich.
Foamalum Corp., 508 Water St., Peru, Ill.
Follansbee Steel Corp., Sheet Metal Specialty Div., P.O. Box 567, Follansbee, W. Va.
Fome-Cor Corp., 812 Monsanto Ave., Springfield 2, Mass.
Food Machinery & Chemical Corp., 161 E 42nd St., New York 17, N.Y.
Chemicals & Plastics Div. (Ad p 214)
161 E 42nd St., New York 17, N.Y.
F M C Organic Chemicals Div., 161 E 42nd St., New York 17, N.Y.
Sonith Foundries Div., 50 Shelby St., Indianapolis 6, Ind.
Foote Mineral Co., 18 W Chelten Ave., Philadelphia 44, Pa.
Fordsell Machine Products Co., 4433 E 8 Mile Rd., Warren, Mich.
Forest City Foundries Co., 2500 W 27th St., Cleveland 13, Ohio
Forg, Peter Mfg. Co., Park St., Somerville 43, Mass.
Formed Tubes, Inc., Prairie & Albert Sts., Sturgis, Mich.
Fort Howard Steel & Wire Co., 200 9th St., Green Bay, Wis.
Fort Wayne Metals, Inc., 3211 MacArthur Dr., Fort Wayne 6, Ind.
Fort Worth Steel & Machinery Co., 3504 Jackson St., Fort Worth, Tex.
Foss Mfg. Co., P.O. Box 553, Twin Falls, Id.
Foster Aluminum Alloy Products Corp., Pearl St., Forestville, N.Y.
Foster Grant Co., 289 N Main St., Leominster, Mass.
Foster Wheeler Corp., 165 Broadway, New York, N.Y.
Fox Co., 3400 Beekman St., Cincinnati, Ohio
Fox Edge Co., Inc., 1995 Middlesex St., Lowell, Mass.
Fox Products Co., 4720 N 18th St., Philadelphia 41, Pa.
Frampton, D.B. & Co., Doweloc Div., 17 S High St., Columbus 15, Ohio
France, J. H. Refractories Co., 710 France Rd., Snow Shoe, Pa.
Frank, J. P. Chemical & Plastic Corp., 5410 Ave. U, Brooklyn 34, N.Y.
Franklin Cotton Mill Co., 1108 Central Pkwy., Cincinnati 10, Ohio
Franklin Glue Co., 119 Chestnut St., Columbus 15, Ohio
Franklin Mineral Products Co., P.O. Box 28, Franklin, N.C.
Frasse, Peter A. & Co., Inc., 17 Grand St., New York 13, N.Y.
Frederick Iron & Steel, Inc., 7th & East Sts., Frederick, Md.
Freeman Chemical Corp., 222 E Main St., Port Washington, Wis.
Fremont Casting Co., 105 Fremont St., Worcester, Mass.
Frenchtown Porcelain Co., Frenchtown, N.J.
Friedrich & Dimmock, Inc., Lincoln Ave., Millville, N.J.
Frisby, R. J. Mfg. Co., 246 N Western Ave., Chicago 12, Ill.
Fromson Orban Co., Inc., 261 Madison Ave., New York, N.Y.
Frontier Bronze Corp. (Ad p 166)
4870 Packard Road, Niagara Falls, N.Y.
Frost Paint & Oil Corp., 1203 NE Tyler, Minneapolis, Minn.
Frost Rubber Co., 1407 N Dayton St., Chicago 22, Ill.
Fry Plastics International, 8601 S Figueroa, Los Angeles 3, Calif.
Fryling Mfg. Co., 531 W 11th St., Erie, Pa.
Fuller, H. B. Co., 1150 Eustis St., St. Paul 8, Minn.
Fuller, W. P. & Co., 301 Mission St., San Francisco, Calif.
Fullerton Mfg. Co., 343 E Santa Fe Ave., Fullerton, Calif.
Fulton Foundry & Machine Co., Inc., Cleveland, Ohio
Fulton Gold Refiners Corp., 71 Fulton St., New York 38, N.Y.
Furane Plastics, Inc., 4516 Brazil St., Los Angeles 39, Calif.

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G. & C. Foundry Co., 2806 W Monroe St., Sandusky, Ohio
G & G Mfg. Co., 3223 W Fillmore St., Chicago 24, Ill.
G.S. Plastics Co., 1300 Brookpark Rd., Cleveland 9, Ohio
G & Z Automatic Products Co., 2434 Brooklyn Rd., Jackson, Mich.
Gale Mfg. Co., 115 N Albion St., Albion, Mich.
Galigher Co., 545 W 8th St., P.O. Box 209, Salt Lake City 10, Utah
Galvicon Corp., 20 Meadow St., Brooklyn 6, N.Y.
Gamble Bros., Inc., Special Products Div., 4601 Allmond Ave., Louisville 9, Ky.
Gantner Screw Products Co., Inc., 20 S Walnut St., Springfield, Ohio
Gar Precision Parts, Inc., 190 Henry St., Stamford, Conn.
Garco Mfg. Co., Inc., 744 N Ada St., Chicago 22, Ill.
Garden State Forge Co., 1501 Jersey St., South Plainfield, N.J.
Garfield Mfg. Co., 10 Midland Ave., Wallington, N.J.
Garlock Packing Co. (Ad p 269)
402 Main St., Palmyra, N.Y.
U.S. Gasket Plastics Div., 600 N 10th St., Camden 1, N.J.
Gartland Foundry Co., 4th & Grant Sts., Terre Haute, Ind.
Gartland-Haswell Foundry, Inc., 430 W Park St., Sidney, Ohio
Gary Lynn Co., 926 York St., Cincinnati 14, Ohio
Gary Steel Products Corp., P.O. Box 449, Lynchburg, Va.
Gates Engineering Co., 100 S West St., Wilmington 99, Del.
Gates Rubber Co., 999 S Broadway, Denver, Colo.
Gatke Corp., Engineering Div., 228 N LaSalle St., Chicago 1, Ill.
Geauga Industries Co., Middlefield, Ohio
General Alloys Co., 405 W 1st St., South Boston, Mass.
General Aluminum Mfg. Co., 3027 E 55th St., Cleveland 27, Ohio
General American Transportation Corp., 135 S LaSalle St., Chicago 3, Ill.
Kanigen Div., 135 S LaSalle St., Chicago 3, Ill.
Parker-Kalon Div., 1 Peekay Dr., Clifton, N.J.
Plastics Div., 135 S LaSalle St., Chicago 3, Ill.
Plate & Welding Div., 135 S LaSalle St., Chicago 3, Ill.
General Aniline & Film Corp., Antara Chemicals Div., 435 Hudson St., New York 14, N.Y.
General Asbestos Gasket Mfg. Corp., 1721 S 7th St., St. Louis 4, Mo.
General Astrometals Corp., 320 Yonkers Ave., Yonkers, N.Y.
General Cable Corp., 730 3rd Ave., New York 17, N.Y.
General Chain & Mfg. Corp., 3182 Beekman St., Cincinnati 23, Ohio
General Drop Forge Corp., 1738 Elmwood Ave., Buffalo, N.Y.
General Dynamics Corp., Liquid Carbonic Div., 135 S LaSalle St., Chicago 3, Ill.
General Electric Co., 1 River Rd., Schenectady 5, N.Y.
Chemical Materials Dept. (Ad p 272)
1 Plastics Ave., Pittsfield, Mass.
Chemical & Metallurgical Div., 2200 N 22nd St., Decatur, Ill.
Foundry Dept., 1 River Rd., (Bldg. 96), Schenectady, N.Y.
Insulating Materials Dept., 23 River Rd., Schenectady 5, N.Y.
Laminated Products Dept. (Ad p 369)
Coshocton, Ohio
Lamp Wire & Phosphors Dept., 21800 Tungsten Rd., Cleveland 17, Ohio
Metallurgical Products Dept., P.O. Box 237, Roosevelt Park Annex, Detroit 32, Mich.
Plastics Dept., N 22nd St., Decatur, Ill.
Silicone Products Dept., Waterford, N.Y.
General Engineering Works, 4701 W Division St., Chicago 51, Ill.

General Extrusions, Inc. (Ad p 415)
4040 Lake Park Rd., Youngstown 12, Ohio

General Findings & Supply Co., Industrial Div. (Ad p 368)
School & Pearl Sts., Attleboro, Mass.

General Foundry & Mfg. Co., Flint, Mich.

General Gasket, Inc., Middletown, Conn.

General Industries Co., Molded Plastic Div., Taylor & Olive Sts., Elyria, Ohio

General Iron Works Co., P.O. Box 2490, Denver 1, Colo.

General Malleable Corp., 706 E Main St., Waukesha, Wis.

General Metals Corp., 550 85th Ave., Oakland, Calif.

General Metals Powder Co., 130 Elinor Ave., Akron 5, Ohio

General Mills, Inc., Chemical Div., S Kensington Rd., Kankakee, Ill.

General Motors Corp., General Motors Bldg., Detroit, Mich.
Brown Lipe Chapin Div., GM Circle, Town Line Rd., Syracuse 1, N.Y.
Central Foundry Div., 37 Florence St., Saginaw, Mich.
Delco Moraine Div., 1420 Wisconsin Blvd, Dayton 1, Ohio
Fabricast Div., 3rd & Monon, Bedford, Ind.

Rochester Products Div. (Ad p 411)
1000 Lexington Ave., Rochester 3, N.Y.

General Plastics Corp., 1400 N Washington St., Marion, Ind.

General Plastics Corp., 55 La France Ave., Bloomfield, N.J.

General Plastics Mfg. Co., 3481 S 35th St., Tacoma 9, Wash.

General Powdered Metal Products, Inc., Holly Corp., 523 West Ave., Norwalk, Conn.

General Refractories Co., 1520 Locust St., Philadelphia 2, Pa.

General Screw Products Corp., 1190 Brooks Ave., Rochester 19, N.Y.

General Sintering Corp., 1830 N 32 Ave., Melrose Park, Ill.

General Smelting Co., 2901 E Westmoreland St., Philadelphia, Pa.

General Steel Castings Corp., 1417 State St., Granite City, Ill.

General Tire & Rubber Co., 1700 Factory Ave., Marion, Ind.
Bolta Products Div., 70 Garden St., Lawrence, Mass.
Chemical Div., 1485 Archwood, Akron 9, Ohio
Industrial Products Div., Wabash, Ind.
Marion Div., Marion, Ind.
Respro Div., 530 Wellington Ave., Cranston 10, R.I.
Textileather Div., 607 Madison Ave., Toledo 8, Ohio

General Veneer Mfg. Co., 8652 Otis, South Gate, Calif.

Genesee Laboratory, Inc., 16 Garden St., Auburn, N.Y.

George, P. D. Co., 5100 N 2nd St., St. Louis, Mo.

Georgia Iron Works, Augusta, Ga.

Georgia-Pacific Corp., Equitable Bldg., Portland, Ore.

Gerstenslager Co., E Bowman St., Wooster, Ohio

Geuder, Paeschke & Frey Co., 324 N 15th St., Milwaukee 1, Wis.

Giant Grip Mfg. Co., 113 Osceola St., Oshkosh, Wis.

Gibson Electric Sales Corp. (Ad p 408)
Box 545, Delmont, Pa.

Gibson & Kirk Co., Warner & Bayard St., Baltimore 30, Md.

Gilbert & Bennett Mfg. Co., Georgetown, Conn.

Gilbert Brass Foundry Co., 5036 Ferlin Ave., St. Louis 15, Mo.

Gillett & Eaton, Inc., 847 Doughty, Lake City, Minn.

Gilman Bros. Co., Gilman, Conn.

Gisholt Plastics, 1245 E Washington Ave., Madison 10, Wis.

Gladding, McBean & Co., Technical Ceramic Div., 1551 S Primrose Ave., Monrovia, Calif.

Glamorgan Pipe and Foundry Co., P.O. Drawer 740, Lynchburg, Va.

Glasby, J. P. Mfg. Co., Inc., 1 Montgomery St., Belleville 9, N.J.

Glaskyd, Inc., Eckel Rd., Perrysburg, Ohio

Glass Laboratories, 863 65th St., Brooklyn 20, N.Y.

Glass Reinforced Plastics Corp., 405 W Sophia, Maumee, Ohio

Glastic Corp., 4321 Glenridge Rd., Cleveland 21, Ohio

Gleason Corp., Anthes Div., 20th St. & Ave. M, Fort Madison, Iowa

Glenn, Joseph & Sons, Inc., Clifton Hts., Pa.

Glidden Co., 1717 Summer St., Hammond, Ind.

Chemical Divs., Metals Dept. (Ad p 397)
1717 Summer St., Hammond, Ind.

Industrial Paint Div. (Ad p 273)
900 Union Commerce Bldg., Cleveland 14, Ohio
Metals Dept., 101 Bridge St., Johnstown, Pa.

Globe Imperial Corp., Plastic-Seal Div., 2038 Kishwaukee, Rockford, Ill.

Globe Industries, Inc., Supermet Div. (Ad p 428)
1466 Cincinnati St., Dayton 8, Ohio

Globe Paint Works, Inc., P.O. Box 36, Williamsport, Pa.

Globe Steel Abrasive Co., 238 1st Ave., Mansfield, Ohio

Globe Union, Inc., Centralab Electronics Div. (Ad p 402)
946 E Keefe Ave., Milwaukee 1, Wis.

Glo-Brite Products, Inc., 6415 N California Ave., Chicago 45, Ill.

Glover Machine Works, Butler St., Marietta, Ga.

Gluntz Brass & Aluminum Foundry Co., 10815 Harvard Ave., Cleveland 5, Ohio

Gold Leaf & Metallic Powders, Inc., 145 Nassau St., New York, N.Y.

Gomar Mfg. Co., Inc., 1501 W Blancke St., Linden, N.J.

Goodrich, B.F. Chemical Co. (Ad pp 266-267)
3135 Euclid Ave., Cleveland 15, Ohio
Hood Rubber Co. Div., 99 Nichols Ave., Watertown, Mass.
Sponge Products Div., Shelton, Conn.

Goodrich, B.F. Industrial Products Co., 500 S Main St., Akron, Ohio

Goodrich-Gulf Chemicals, Inc., 1717 E 9th St., Cleveland 14, Ohio

Goodyear Tire & Rubber Co., 1144 E Market St., Akron 16, Ohio
Chemical Div., 1144 E Market St., Akron 16, Ohio

Gordon Chemicals, Inc., 500 A St., Wilmington 99, Del.

Goshen Rubber Co., Inc., 1525 S 19th St., Goshen, Ind.

Goslin Birmingham Mfg. Co., Inc., 3521 10th Ave. N, Birmingham 1, Ala.

Gossett and Hill Co., 7185 W Bloomingdale, Chicago 35, Ill.

Gotham Plastics Corp., 220 E 134 St., New York 51, N.Y.

Gowanda Furnaces, Inc., 7 Palmer St., Gowanda, N.Y.

Grace, W.R. & Co., 7 Hanover Sq., New York, N.Y.
Davison Chemical Co. Div., Baltimore 3, Md.
Dewey & Almy Chemical Div., 62 Whittemore Ave., Cambridge 40, Mass.
Polymer Chemicals Div., 225 Allwood Rd., Clifton, N.J.

Grafton Foundry Co., 1003 Bridge St., Grafton, Wis.

Gra-Iron Foundry Corp., 501 S 12th Ave., Marshalltown, Iowa

Grammes, L.F. & Sons, Inc., 380 Union St., Allentown, Pa.

Grand Haven Stamped Products Co., Griffen & Madison Sts., Grand Haven, Mich.

Grand Rapids Brass Co., 420 50th St., SW, Grand Rapids 8, Mich.

Grand Rapids Varnish Corp., 1350 Steele St., SW, Grand Rapids, Mich.

Grand Sheet Metal Products Co., Consumer Products Div., 2055 Ruby St., Melrose Park, Ill.

Granite City Steel Co., 20th & State St., Granite City, Ill.

Graphite Metallizing Corp., 1050 Nepperhan Ave., Yonkers 3, N.Y.

Graphite Products Corp., Trumbull County, Brookfield, Ohio

Graphite Specialties Corp. (Ad p 314)
64th St. & Pine Ave., Niagara Falls, N.Y.

Grass, M.J. Machine Products Co., 19 Northampton St., Buffalo 9, N.Y.

Gray-Syracuse, Inc., W Seneca St., Manlius, N.Y.

Great American Industries, Inc., Rubatex Div., Bedford, Va.

Great Lakes Carbon Corp. (Ad p 308)
18 E 48th St., New York 17, N.Y.

Grede Foundries, Inc., 1320 S 1st St., Milwaukee 1, Wis.

Green Bay Foundry & Machine Works, 401 S Broadway, Green Bay, Wis.

Green, A.P. Fire Brick Co., Mexico, Mo.

Green River Steel Corp., P.O. Drawer 637, Owensboro, Ky.

Greenback Industries, Inc., 2527 W Maple Rd., Birmingham, Mich.

Greene, G.G. Corp., Box 900, Warren, Pa.

Greene Mfg. Co., 1028 Douglas Ave., Racine, Wis.

Greene, Tweed & Co., North Wales, Pa.

Greenlee Foundry Co., 4600 W 14th St., Chicago 50, Ill.

Green-Walker Galvanizing Co., Inc., 4932 Jefferson Highway, New Orleans 21, La.

Greer Stop Nut Co., 2620 W Flournoy St., Chicago 12, Ill.

Gregg Metal Products Inc., 1333 N 9th St., Milwaukee 5, Wis.

Gregory Industries Inc., Nelson Stud Welding Div., 28th St. & Toledo Ave., Lorain, Ohio

Gregory Thomas Galvan Works, 4900 Grand Ave., Maspeth 78, N.Y.

Grems Mfg. Co., 5635 S 6th St., Klamath Falls, Ore.

Grey, C.M. Industries, Inc., 358 Central Ave., East Orange, N.J.

Gries Reproducer Corp. (Ad p 468)
153 Beechwood Ave., New Rochelle, N.Y.

Grigoleit Co., 740 E North, Decatur, Ill.

Grimes Mfg. Co., Plastic Research Products, 200 Beech St., Urbana, Ohio

Grimm Foundry Co., Inc., Chimney Rock Rd., Bound Brook, N.J.

Groov-Pin Corp., 1125 Hendricks Causeway, Ridgefield, N.J.

Gross, Willard N., Inc., 224 Highland Ave., Westmont, Collingswood, N.J.

Guarantee Specialty Mfg. Co., 9651 Carr Ave., Cleveland 8, Ohio

Guilfoy Cornice Works, 1234 Howard St., San Francisco 3, Calif.

Gulton Industries, Inc., 212 Durham Ave., Metuchen, N.J.

Gunite Foundries Corp., 302 Peoples Ave., Rockford, Ill.

Gustin-Bacon Mfg. Co., 210 W 10th St., Kansas City 5, Mo.

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H & H Foundry Machine Co., P.O. Box 238, Jeanette, Pa.

H. & H. Screw Products Mfg. Co., 1883 Mineral Spring Ave., North Providence 11, R.I.

H & H Tube & Mfg. Co., 263 N Forman, Detroit 17, Mich.

H & K Machine Service Co., Inc., 6229 Bartmer Ave., St. Louis, Mo.

H. K. Metal Craft Mfg. Corp., 3775 10th Ave., New York, N.Y.

H-P Products, Inc., 510 W Broad St., Louisville, Ohio

HPL Mfg. Co. 15210 Miles Ave., Cleveland 28, Ohio

H & R Plastics Industries, Inc., Box 211, Nazareth, Pa

Haber, 864 W North Ave., Chicago 22, Ill.

Hack, J.H. Mfg. Co., 7049 Lyndon Ave., Detroit 21, Mich.

Hadbar, Inc., 9530 Gidley St., Temple City, Calif.

Hadley Bros.-Uhl Co., 514 Calvary Ave., St. Louis 15, Mo.

Haffner Bros. Co., Hopple St. Central Pkwy., Cincinnati 25, Ohio

Hagstoz, T.B. & Son, 709 Sansom, Philadelphia 6, Pa

Haigh Mfg. Co., 225 E Grand River, Brighton, Mich.

Halex Corp., 26302 W 7 Mile Rd., Detroit 40, Mich.

Hall C.P. Co., 414 S Broadway, Akron 8, Ohio

Hall Mfg. Corp., Rt. 17 & Powers Drive, Paramus, N.J.

Haller, Inc., 16580 Northville Rd., Northville, Mich.

Hallstead Foundry, Inc., Main St., Hallstead, Pa.

Halogen Insulator & Seal Corp., 9960 Pacific Ave., Franklin Park, Ill.

Hamilton Die Cast, Inc., 240 N B St., Hamilton, Ohio

Hamilton Foundry, Inc., 1551 Lincoln Ave., Hamilton, Ohio

Hamilton Watch Co., Precision Metals Div., Lancaster, Pa.

Hampden Brass & Aluminum Co., 262 Liberty St., Springfield, Mass.

Hampton Mfg. Co., 111 Cedar St., New Rochelle, N.Y.

Handy & Harman (Ad pp 151, 467)
82 Fulton St., New York 38, N.Y.

Hanford Foundry Co., 119 S Arrowhead Ave., San Bernardino, Calif.

Hauser Products, Inc., 4034 N Kolmar Ave., Chicago 41, Ill.

Hanlon-Gregory Galvanizing Co., 5515 Butler St., Pittsburgh 1, Pa.

Hanovia Chemical Mfg. Co., 1 Central Ave., East Newark, N.J.

Hansell-Elcock, 485 W 23rd Pl., Chicago 16, Ill.

Harbet Die Casting Corp., 52 E Centre St., Nutley, N.J.

Harcast Co., Inc., 620 E Glenolden Ave., Glenolden, Pa.

Hardinge Mfg. Co., 240 Arch St., York, Pa.

Hardman, H. V. Co., Inc., 577 Cortlandt St., Belleville 9, N.J.

Hardy, Charles, Inc., 420 Lexington Ave., New York 17, N.Y.

Hardy Mfg. Corp., W Pearl St., Union City, Ind.

Harnischfeger Corp., 4400 W National Ave., Milwaukee 46, Wis.

In contacting suppliers, please mention the Materials Selector Issue

Harper, H.M. Co., 8200 Lehigh Ave., Morton Grove, Ill.
Harrington & King Perforating Co., Inc., 5671½ Fillmore St., Chicago 44, Ill.
Harris, Benjamin & Co., 11th & State Sts., Chicago Hts., Ill.
Harrisburg Steel Co., 110 E 42nd St., New York 17, N.Y.
Harsco Corp., 3200 Guardian Bldg., Detroit 26, Mich.
Ainsworth-Precision Castings Co. Div., 3200 Guardian Bldg., Detroit 26, Mich
Taylor-Wharton Co., High Bridge, N.J.
Harshaw Chemical Co., 1945 E 97th St., Cleveland 6, Ohio
Hartford Electric Steel Corp., 540 Flatbush Ave., Hartford 10, Conn.
Hartglas Co., 1302 Expressway Dr., Toledo 8, Ohio
Hartwell, H.N. & Son, Inc., Park Square Bldg., 31 St. James St., Boston 16, Mass.
Harvey Aluminum, 19200 S Western Ave., Torrance, Calif.
Harvill Corp., 6251 W Century Blvd., Los Angeles 45, Calif.
Harvin & Co., Box 83, Federal St., Kenilworth, N.J.
Harwood Screw Products, Inc., 1620 E Pleasant St., Springfield, Ohio
Hassall, John Inc., P.O. Box 2277, Westbury, N.Y.
Hastings & Co., Inc., 2314 Market St., Philadelphia 3, Pa.
Hauger-Beegle Asso., Inc., 900 W 49th Pl., Chicago 9, Ill.
Hauser Products, Inc., 4034 N Kolmar Ave., Chicago 41, Ill.
Haveg Industries, Inc., 900 Greenbank Rd., Wilmington 8, Del.
Hawkeye Rubber Mfg. Co., 915 Shaver Road NE, Cedar Rapids, Iowa
Hawkridge Bros. Co., 303 Congress St., Boston 10, Mass.
Hawley Products Co., 333 N 6th St., St. Charles, Ill.
Haws Refractories Co., 407 Main St., Johnstown, Pa.
Hay, James E. Co., Inc., 244 Smith St., Lowell, Mass.
Hayden Mica Co., Inc., Main St., Wilmington, Mass.
Hayden Wire Works, Inc., P.O. Box 146, West Springfield, Mass.
Haydon Corp., 3815 9th Ave., New York 34, N.Y.
Hayes Adhesive Co., Inc., Union Blvd. at Brown Ave., St. Louis 15, Mo.
Hayman, Michael & Co., 856 E Ferry St., Buffalo 11, N.Y.
Hays Mfg. Co., 80 W 12th St., Erie, Pa.
Haywilk Galvanizing Inc., P.O. Box 372, Harvey, La.
Hazledine, E.T. Co., 231 S 1st St., Terre Haute, Ind.
Headford Bros. & Hitchins Foundry Co., 1502 Westfield Ave., Waterloo, Iowa
Headly Mfg. Co., 4376 W Ogden Ave., Chicago 23, Ill.
Heatbath Corp., P.O. Box 78, Springfield 1, Mass.
Heil Process Equipment Corp., 12901 Elmwood Ave., Cleveland 11, Ohio
Held, O.P. Inc., 761 Nepperhan Ave., Yonkers 3, N.Y.
Heli-Coil Corp., Shelter Rock Lane, Danbury, Conn.
Grip Nut Co., Sub., Broad & Maple Sts., S Whitley, Ind.
Heller, A.B. Screw Products, Inc., 14571 Lesure Ave., Detroit 27, Mich.
Heller Tool Co., Heller Dr., Newcomerstown, Ohio
Helmick Foundry-Machine Co., P.O. Box 71, Fairmont, W. Va.
Hendrick Mfg. Co., 30 Dundaff St., Carbondale, Pa.
Henefelt Precision Products, Inc., P. O. Box 1429, Clearwater, Fla.
Henrite Products Corp., Ironton, Ohio
Heppenstall Co., 4620 Hatfield St., Pittsburgh 1, Pa.
Hercules Fastener Co., 2722 N Clybourn St., Chicago 14, Ill.
Hercules Powder Co. Inc., Delaware Trust Bldg., Wilmington 99, Del.
Heresite & Chemical Co., Manitowoc, Wis.
Herker Screw Products, Inc., 4924 N 125th St., Butler, Wis.
Herman Machine & Tool Co., Tallmadge, Ohio
Hersey Metal Products, Inc., Derby, Conn.
Hettleman, K. & Sons, Inc., 9th & Patapsco Aves., Baltimore 25, Md.
Hewitt, John Foundry Co., 15-29 Sherman Ave., East Newark, N.J.
Hewitt-Robins, Inc., 666 Glenbrook Rd., Stamford, Conn.
Hexcel Products, Inc., 2332 4th St., Berkeley, Calif.
Heyden Newport Chemical Corp., American Plastics Corp. Div., 342 Madison Ave., New York 17, N.Y.
Heyplan Mfg. Co., E Michigan Ave., Kenilworth, N.J.
Hibben & Co., 9376 S Ewing Ave., Chicago, Ill.
Hica, Inc., 1431 W 59th St., Shreveport, La.
Hicks Corp., Hyde Park Ave., Boston, Mass.
Higbie Mfg. Co., Avon Tube Div., Klein Rd., Rochester, Mich.
High Vacuum Equipment Corp., 2 Churchill Rd., Hingham, Mass.
Hi-Grade Alloy Corp., 3034 E 95th St., Chicago 17, Ill.
Hilfinger Corp., 1880 Westwood Ave., Toledo 7, Ohio
Hiller Aircraft Corp., Adhesive Engineering Div., 1411 Industrial Rd., San Carlos, Calif.
Hills-McCanna Co., 4600 Touhy Ave., Chicago 46, Ill.
Hilo Varnish Corp., Industrial Finishes Div., 376 3rd St., Everett 49, Mass.
Himmel Bros. Co., 1409 Dixwell Ave., Hamden, Conn.
Hi-Shear Corp., 2600 W 247th St., Torrance, Calif.
Hitchiner Mfg. Co., Inc., P.O. Box 350, Milford, N.H.
Hitemp Wires, Inc., 1200 Shames Dr., Westbury, N.Y.
Hobart Bros. Co., 1221 Hobart Rd., Troy, Ohio
Hobbs, Clinton E. Co., 203 Chelsea St., Everett 49, Mass.
Hodges, William & Co., Inc., American St. at Columbia Ave., Philadelphia 22, Pa.
Hodgman Rubber Co., Tripp St., Framingham, Mass.
Hodgson Foundry Co., 2012 W 13th St., Chicago 8, Ill.
Hoeganaes Sponge Iron Corp. (Ad p 428)
Riverton, N.J.
Hoffman Bronze & Aluminum Casting Co., 1000 Addison Rd., Cleveland 3, Ohio
Hofford Varnish Co., Inc., Broad & 14th Sts., Carlstadt, N.J.
Hohwieler Rubber Co., Inc., 32 W Bridge St., Morrisville, Pa.
Hollingsworth & Vose Co., Washington St., East Walpole, Mass.
Holo-Krome Screw Corp., P.O. Box 98, Elmwood Branch, Hartford 10, Conn.
Holt Products Co., Walnut St., Holt, Mich.
Home Rubber Co., 30 Woolverton Ave., Trenton, N.J.
Homestead Valve Mfg. Co., P.O. Box 348 Coraopolis, Pa.
Hommel, O. Co., P.O. Box 475, Pittsburgh 30, Pa.
Hoofer Mfg. Co., 544 W Lake St., Chicago 6, Ill.
Hooker Chemical Corp., 31 Iroquois St., Niagara Falls, N.Y.
Durez Plastics Div. (Ad pp 262-263)
1967 Walck Rd., North Tonawanda, N.Y.
Hoover Co., Die Casting Div., 101 E Maple St., North Canton, Ohio
Horn, A. C. Companies, 2133 85th St., North Bergen, N.J.
Horton-Angell Co., 31 Bicknell St., Attleboro, Mass.
Hoskins Mfg. Co. (Ad p 148)
4445 Lawton Ave., Detroit 8, Mich.
Houdaille Industries, Inc., Fairmount Tool & Forging, Inc. Sub., 10611 Quincy Ave., Cleveland 6, Ohio
Houghton, E.F. & Co., 303 W Lehigh Ave., Philadelphia 33, Pa.
Houston Blow Pipe & Sheet Metal Works, P.O. Box 1692, Houston 1, Tex.
Houston Reinforced Plastics Co., Inc., 1124 Silber L Road, Houston 24, Tex.
Howard Foundry Co., 1700 N Kostner Ave., Chicago 29, Ill.
Howe Sound Co., 500 5th Ave., New York, N.Y.
Austenal Co. Div., 224 E 39th St., New York, N.Y.
Peerless Roll Leaf Co. Div., 4511 New York Ave., Union City, N.J.
Hoyt, Charles D. Co., Inc., 1118 Forest Ave., Mishawaka, Ind.
Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7, Mich.
Hudsar, Inc., 567 Wilson Ave., Newark 5, N.J.
Hudson Cush-N-Foam Corp., 309 River Rd., Edgewater, N.J.
Hudson Screw Machine Products Co., 4500 W Augusta Blvd., Chicago 51, Ill.
Hudson Wire Co., Pequot Wire Cloth Co. Div., 35 Hoyt St., Norwalk, Conn.
Hughes Glue Co., 3500 St. Aubin Ave., Detroit 7, Mich.
Hughes Tool Co., 5425 Polk Ave., P.O. Box 2539, Houston 1, Tex.
Hull, R.O. & Co., Inc., 1300 Parsons Ct., Rocky River 16, Ohio
Humble Oil & Refining Co., Enjay Chemical Co. Div. (Ad pp 218-219, 230)
15 W 51st St., New York 19, N.Y.
Humphrey Castings, Inc., 3944 Riley St., San Diego 10, Calif.
Hungerford Plastics Corp., P.O. Box 376, Morristown, N.J.
Hunt Screw & Mfg. Co., 4117 N Kilpatric Ave., Chicago 41, Ill.
Hunter Corp., P. O. Box 307, Blairsville, Pa.
Hunter Engineering Co., 1495 Columbia Ave., Riverside, Calif.
Hunt-Spiller Mfg. Corp., 383 Dorchester Ave., Boston 82, Mass.
Huron Automatic Screw Co., P.O. Box 66, Port Huron, Mich.
Huron Forge & Machine Co., 9041 Alpine Ave., Detroit 4, Mich.
Huyck Corp., Rensselaer, N.Y.
Hyde, A.L. Co. (Ad p 408)
Main St., Grenloch, N.J.
Hydrawlik Co., 131-137 E 1st St., Roselle, N.J.
Hydroforming Co. of America, 7400 W Lawrence Ave., Chicago 31, Ill.
Hydrometals, Inc., Illinois Zinc Co. Div., 230 N Michigan Ave., Chicago 1, Ill.
Hy-Level Screw Products Co., 2615 Scranton Rd., Cleveland 13, Ohio
Hysol Corp. (Ad p 274)
Olean, N.Y.

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I-F Mfg. Co., New Philadelphia, Ohio
Ideal Can Co., 68 Vine St., Everett 49, Mass.
Ideal Metal Products Co., 4842 W Kinzie St., Chicago 44, Ill.
Illinois Forge, Inc., Rock Falls, Ill.
Illinois Iron & Bolt Co., Carpentersville, Ill.
Illinois Precise Casting Co., 903 N Spaulding Ave., Chicago 51, Ill.
Illinois Smelting & Refining Co., 3637 S Albany Ave., Chicago 32, Ill.
Illinois Tool Works, 2511 N Keeler Ave., Chicago, Ill.
Fastex Div., 195 Algonquin Rd., Des Plaines, Ill.
Shakeproof Div., St. Charles Rd., Elgin, Ill.
Imco Container Corp., 75th & Cleveland Sts., Kansas City, Mo.
Impact Extrusions, Inc., 2102 Calumet Rd., Valparaiso, Ind.
Impax, Inc., P.O. Box 5841, Ferguson 21, Mo.
Improved Seamless Wire Co., 775 Eddy St., Providence 5, R.I.
Imsande Screw Products Co., 3517 Cardiff Ave., Cincinnati 9, Ohio
Inder Corp., Indianapolis, Ind.
Independence Stove & Mfg. Co., Hayward & Cottage Sts., Independence, Mo.
Independent Galvanizing Co., 37 Verona Ave., Newark 4, N.J.
Indiana Brass Co., Inc., P.O. Box 113, Frankfort, Ind.
Indiana Forge & Machine Co., 3468 Watling St., East Chicago, Ind.
Indiana General Corp., General Ceramics Div., Keasbey, N.J.
Indiana Steel Products Co., Valparaiso, Ind.
Indiana Steel & Wire Co., Inc., 2200 E Jackson St., Muncie, Ind.
Indium Corp. of America (Ad p 154)
1676 Lincoln Ave., Utica 1, N.Y.
Indus Corp., 1815 Madison Ave., Indianapolis 25, Ind.
Industrial Chromium Corp., 109 Lyman St., Holyoke, Mass.
Industrial Equipment Co., 115 Ohio St., Minster, Ohio
Industrial Metal Protectives, Inc., 401 Homestead Ave., Dayton 8, Ohio
Industrial Mica Corp., 223 S Van Brunt St., Englewood, N.J.
Industrial Molded Products Co., Inc., Hwy. 53 at U.S. 14, Palatine, Ill.
Industrial Pipe & Supply Co., 5100 W 16th St., Cicero 50, Ill.
Industrial Plastic Fittings Co., 3891 W 150th St., Cleveland 11, Ohio
Industrial Plastics Corp., 816 W Beardsley Ave., Elkart, Ind.
Industrial Polychemical Service, P.O. Box 423, Gardena, Calif.
Industrial Precision Products, 3047 Carroll, Chicago 12, Ill.
Industrial Rayon Corp., 500 5th Ave., New York 36, N.Y.
Industrial Sapphire Co. (Ad p 314)
Box 22, Quakertown, Pa.
Industrial Stainless Steels, Inc., 255 Bent St., Cambridge 41, Mass.
Industrial Synthetics Corp., 225 North Ave., Garwood, N.J.
Industrial Tectonics, Inc., 3686 Jackson Rd., Ann Arbor, Mich.
Industrial-Ferguson Foundry Corp., Route 22, Union, N.J.
Ingalls Iron Works Co., 620 4th Ave., Birmingham, Ala.
Ingersoll-Rand Co., Phillipsburg, N.J.
Ingram-Richardson, Inc., 1460 Jefferson Rd., Frankfort, Ind.
Ingram-Richardson Mfg. Co., P.O. Box 191, Beaver Falls, Pa.
Inland Mfg. Co., 1108 Jackson St., Omaha 2, Neb.
Inland Steel Co., 30 W Monroe St., Chicago 3, Ill.

Imshield Die & Stamping Co., 1931 Manhattan Blvd., Toledo 8, Ohio
Inspiration Consolidated Copper Co., 25 Broadway, New York 4, N.Y.
Instrument Parts Corp., Snowden Ave. & Water St., Ossining, N.Y.
Instrument Specialties Co., Inc., 244 Bergen Blvd., Little Falls, N.J.
Insulation Mfrs. Corp., 565 W Washington Blvd., Chicago 6, Ill.
Insulation Products Co., P.O. Box 5679, Pittsburgh 8, Pa.
Interchemical Corp. (Ad p 460)
67 W 44th St., New York 36, N.Y.
Angier Adhesives Div., 120 Potter St., Cambridge 42, Mass.
Finishes Div., 224 McWhorter St., Newark 5, N.J.
International Balsa Corp., 100 Boyd Ave., Jersey City 4, N.J.
International Harvester Co., 180 Michigan Ave., Chicago, Ill.
International Minerals and Metals Corp., 11 Broadway, New York 4, N.Y.
Wisconsin Steel Co. Div., 180 N Michigan Ave., Chicago 1, Ill.
International Nickel Co., Inc., 67 Wall St., New York 5, N.Y.
Huntington Alloy Products Div., Huntington 17, W. Va
Platinum Metals Div., 67 Wall St., New York 5, N.Y.
International Optical Co., Inc., 47 Urban Ave., Westbury, L.I., N.Y.
International Packings Corp. (Ad p 435)
Bristol, N.H.
International Paper Co., Long-Bell Div., Longview, Wash.
International Powder Metallurgy Co., Inc., 439 W Main St., Ridgway, Pa.
International Silver Co., Eyelet Specialty Div., P.O. Box 179, Wallingford, Conn.
Interstate Drop Forge Co., 4051 N 27th St., Milwaukee 16, Wis.
Investment Casting Co., 60 Brown Ave., Springfield, N.J.
Iowa Malleable Iron Co., 9th & Kirkwood Ave., Fairfield, Iowa
Ironton Fire Brick Co., Box 536, Ironton, Ohio
Irvington Form & Tank Corp., 100 William St., New York 38, N.Y.
Irwin-Sensenich Corp., P. O. Box 311, Irwin, Pa.
Industrial & Furnace Car Div., P.O. Box 311, Irwin, Pa.
Isaacson Iron Works, 8531 E Marginal Way, Seattle 14, Wash.
Isocyanate Products, Inc., 900 Wilmington Rd., New Castle, Del.
Iten Fibre Co., Box 20, Ashtabula, Ohio

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Jackson Auto Radiator, 1515 Altgeld St., Chicago 14, Ill.
Jackson Steel Products, Inc., 32 Rodney St., Brooklyn 11, N.Y.
James Hill Mfg. Co., 20 Gordon Ave., Providence 5, R.I.
Jamestown Finishes, 125 Blackstone Ave., Jamestown, N.Y.
Jamestown Malleable Iron Corp., 3444 Blackstone Ave., Jamestown, N.Y.
Jamison Plastic Corp., 1255 Newbridge Rd., North Bellmore, L.I., N.Y.
Janney Cylinder Co., 7401 State Rd., Philadelphia 36, Pa.
Jaques Co., 67 Batterymarch St., Boston 10, Mass.
Jarco Metal Products, Portland Ave., Westbury, L.I., N.Y.
Jarl Extrusions, Inc. (Ad p 426)
Linden Ave., East Rochester, N.Y.
Jasco Aluminum Products Co., New Hyde Park, N.Y.
Jasper Lacquer Co., Inc., Vine St., Jasper, Ind.
Jelenko, J. F. Co., Inc., 136 W 52nd St., New York 19, N.Y.
Jelliff, C.O. Mfg. Corp., Pequot Rd., Southport, Conn.
Jema-American, Inc., 181 South St., Newark 5, N.J.
Jersey Plastic & Die Casting Co., 151 Shaw Ave., Irvington, N.J.
Jervis Corp., 2900 Wilson Ave., Grandville, Mich.
Jessop Steel Co., 500 Green St., Washington, Pa.
Jet Specialties Co., Inc., 941 N Eastern Ave., Los Angeles, Calif.
Jobbins, William F. Inc., Aurora, Ill.
Johns-Manville Corp., 22 E 40th St., New York 16, N.Y.
Dutch Brand Div., 7800 Woodlawn Ave., Chicago 19, Ill.
Glass Textiles Div., 1810 Madison Ave., Toledo 2, Ohio
Johnson, A. & Co., Inc., 21 West St., New York 6, N.Y.
Johnson Bronze Co., S Mill St., New Castle, Pa.
Johnson Metal Hose, Inc., 10 Sperry St., Waterbury 20, Conn.
Johnson Plastic Corp., Box 312, Chagrin Falls, Ohio
Johnson Rubber Co., 111 Vine St., Middlefield, Ohio
Johnson, S.C. & Son, Inc., Racine, Wis.
Johnson Steel and Wire Co., Inc., 53 Wiser Ave., Worcester, Mass.
Johnston & Funk Titanium Corp., W Kamrow Ave., Wooster, Ohio
Johnstone Foundries, Inc., P.O. Box 549, Grove City, Pa.
Jolans Metal Products Co., 224 Sussex Ave., Newark 4, N.J.
Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh 30, Pa.
Stainless & Strip Div., Stainless—P.O. Box 4606, Detroit 34, Mich.; Strip—1939 Teeghly St., Youngstown 1, Ohio
Jordan Co., 51st St. & Merrimac Ave., Chicago 38, Ill.
Jordan Machine Products, Inc., 3611 St. Aubin Ave., Detroit 7, Mich.
Jordan-Rogers Co., 640 N Cypress, Orange, Calif.
Joseff-Hollywood Co., 129 E Providencia, Burbank, Calif.
Joslyn Mfg. & Supply Co., 155 N Wacker Dr., Chicago 6, Ill.
Joslyn Pacific Co., 5100 District Blvd., Los Angeles 11, Calif.
Joslyn Stainless Steels, 155 N Wacker Dr., Chicago 6, Ill.
Joymont Plastics, Inc., 710 S State St., Girard, Ohio
Judd Industries, Inc., 3315 Vega Ave., Cleveland 13, Ohio
Judson Rubber Works, Inc., 4107 W Kinzie St., Chicago 24, Ill.

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K-D Mfg. Co., P. O. Box 912, Cleburne, Tex.
K. & L. Plating Co., 535 E Mifflin St., Lancaster, Pa.
K S H Plastics, Inc., Hwy. 30, High Ridge, Mo.
KSM Products, Inc., 301 New Albany Rd., Moorestown, N.J.
Kaiser Aluminum & Chemical Sales, Inc., 919 Michigan Ave., Chicago 11, Ill.
Kaiser Steel Corp., Kaiser Center, 300 Lakeside Dr., Oakland 12, Calif.
Kamin Die Casting & Mfg. Co. 3315 N Knox, Chicago 41, Ill.
Kanawha Mfg. Co., Charleston, W. Va.
Kansas City Hay Press Co., 801 Woodswether Rd., Kansas City 5, Mo.
Kanthal Corp., Amelia Pl., Stamford, Conn.
Kassel Export Co., Inc., 100 S Van Brunt St., Englewood, N.J.
Katelman Foundry & Mfg. Co., 238 S 11th St., Council Bluffs, Iowa
Kaufman Glass Co., 1209-21 French St., Wilmington 99, Del.
Kawecki Chemical Co., 220 E 42nd St., New York 17, N.Y.
Kawneer Co., 1105 N Front St., Niles, Mich.
Kay-Bee Machine Products Co., 2776 S 34 St., Milwaukee 15, Wis.
Kay-Brunner Steel Products, Inc., 999 Meridian Ave., Alhambra, Calif.
Kaye-Tex Mfg. Corp., Kaykor Industries, Inc. Div., Yardville, N.J.
Keasbey & Mattison Co., Butler Ave., Ambler, Pa.
Keen Foundry Co., Inc., E Main & E Jerr Sts., Griffith, Ind.
Kees, F.D. Mfg. Co., 700 Park St., Beatrice, Neb.
Keilite Corp., Bldg. 15, 81 Industrial Rd., Berkeley Heights, N.J.
Keller Products, Inc., 37 Union, Manchester, N.H.
Kelley Mfg. Co., 4800 Clinton Dr., P.O. Box 17, Houston 1, Tex.
Kelly Foundry Co., 1704 Wharton St., Pittsburgh 3, Pa.
Kelsey-Hayes Co., 3600 Military Ave., Detroit, Mich.
Heintz Div., Front St. & Olney Ave., Philadelphia 20, Pa.
Metals Div., New Hartford, N.Y.
Kendall Co., Walpole, Mass.
Fiber Products Div., Walpole, Mass.
Polyken Div., 309 W Jackson Blvd., Chicago 6, Ill.
Kenmore Machine Products, Inc., 15 Depew Ave., Lyons, N.Y.
Kennametal, Inc. (Ad p 323)
Lloyd Ave., Latrobe, Pa.
Kennatrack Corp., Engineered Nylon Products Div., 2530 By-Pass Rd., Elkhart, Ind.
Kennecott Copper Corp., 161 E 42nd St., New York, N.Y.
Chase Brass & Copper Co. Sub., 236 Grand St., Waterbury 20, Conn.
Okonite Co. Sub., 220 Passaic St., Passaic, N.J.
Kennedy Automatic Products, Inc., 406 S Linden St., Marshall, Mich.
Kenosha Automatic Products Co., P.O. Box 630, Kenosha, Wis.
Kensico Tube Co., Hubbell & RR Aves., Mt. Kisco, N.Y.
Kent Castings Corp., 200 Garden St., Grand Rapids 7, Mich.
Kent County Galvanizing Co., 15 Earlham Way, Hillsgrove 5, R.I.
Keolyn Plastics, Inc., 2731 N Pulaski Rd., Chicago 39, Ill.
Kerrco, Box 4178, Lincoln 7, Neb.
Kerr-Lakeside Industries, Inc., 21850 St. Clair Ave., Cleveland 17, Ohio
Kester Solder Co., 4201 Wrightwood Ave., Chicago 39, Ill.
Kewaunee Engineering Corp., N Main St., Kewaunee, Wis.
Keystone Carbon Co., 1935 State St., St. Marys, Pa.
Keystone Drawn Steel Co., Main & Bridge Sts., Spring City, Pa.
Keystone Forging Co., Northumberland, Pa.
Keystone Plastics, Inc., 282 Badger Ave., Newark, N.J.
Keystone Refining Co., Inc., Garden St., Philadelphia 37, Pa.
Keystone Steel & Wire Co., Peoria 7, Ill.
Kickhaefer Mfg. Co., 901 S 2nd St., Milwaukee 4, Wis.
King, Alfred B. Co., Devine St., North Haven, Conn.
King Fifth Wheel Corp., 2915 N 2nd Ave., Philadelphia 33, Pa.
King Laboratories, Inc., 127 Solar St., Syracuse 3, N.Y.
King-Seeley Thermos Co., 720 Norris St., Ypsilanti, Mich.
Albert Lea Foundry-Queen Products Div., 902-910 E Main St., Albert Lea, Minn.
Central Specialty Div., 720 Central Ave., Ypsilanti, Mich.
Kingsport Foundry & Mfg. Corp., E Sullivan & Main Sts., Kingsport, Tenn.
Kinkead Industries, Inc., 5860 N Pulaski Rd., Chicago 30, Ill.
Kiowa Corp., Marshalltown, Iowa
Kirchhof Patent Co., Inc., Dietze Bldg., 60-64 Union St., Newark 5, N.J.
Kirk, F.J. Co., Inc., 140 Brook St., Clinton, Mass.
Kirk, Morris P. & Son, 2700 S Indiana St., Los Angeles 23, Calif.
Kirk & Blum Mfg. Co., 3215 Forrer St., Cincinnati 9, Ohio
Kirkhill Rubber Co., Brea, Calif.
Kish Industries, Inc., 1301 N Turner St., Lansing 6, Mich.
Kleiner Metal Specialties, Inc., P.O. Box K, Dunellen, N.J.
Klincher Locknut Corp., 2153 Hillside Ave., Indianapolis 18, Ind.
Kling Metal Spinning & Stamping Co., 245-247 Centre St., New York 13, N.Y.
Klinzing, A.F. Co., Inc., 921 A 2nd St., Milwaukee 4, Wis.
Klise Mfg. Co., 50 Cottage Grove St., Grand Rapids 2, Mich.
Knapp Mills, Inc., 23-17 Borden Ave., Long Island City 1, N.Y.
Knight, Maurice A. Co., 171 Kelly Ave., Akron 9, Ohio
Knoedler Chemical Co., 651 High St., Lancaster, Pa.
Knowlton Bros., Inc. (Ad p 312)
215 Factory, Watertown, N.Y.
Kobel, W.R. Sheet Metal Products, 148 W 21st St., Ogden, Utah
Koch, H. & Sons, P.O. Box 125, Corte Madera, Calif.
Koehler Mfg. Co., 395 Lincoln St., Marlboro, Mass.
Koehring Co., Milwaukee, Wis.
Kohn Engineering Corp., 8830 S Telegraph Rd., Taylor Center, Mich.
Kopp Glass, Inc. (Ad p 311)
Swissvale, Pittsburgh 18, Pa.
Koppers Co., Inc., Koppers Bldg., Pittsburgh 19, Pa.
Plastics Div. (Ad pp 228-229)
Koppers Bldg., Pittsburgh 19, Pa.
Korhumel Steel and Aluminum Co., 2424 Oakton St., Evanston, Ill.
Koster-Keunen Mfg. Co., Inc., Bourne Blvd., Sayville, N.Y.
Koven, L.O. & Brother, Inc., 154 Ogden Ave., Jersey City 7, N.J.
Kralay Plastic Pipe Co., Inc., 4710-20 E Washington Blvd., Los Angeles 22, Calif.
Kramer, C.P. Co., 9230 W Belmont Ave., Franklin Park, Ill.
Kramer, H. Co., Ajax Metal Div., 46 Richmond St., Philadelphia 23, Pa.
Kramer Bros. Foundry Co., 17 Dell St., Dayton 4, Ohio
Kraus Research Labs, Cockeysville, Md.
Kroh Wagner, 2331 N Pulaski Rd., Chicago 39, Ill.
Krone, Paul Die Casting Co., 1811 N Kostner Ave., Chicago 39, Ill.
Kropp Forge Co., 5301 W Roosevelt Rd., Chicago 50, Ill.
Krueger Fabricating Co., Inc., 257 W Badger Road, Madison 5, Wis.
Krueger & Hudepohl, Inc., 1041 Evans St., Cincinnati 4, Ohio

In contacting suppliers, please mention the Materials Selector Issue

Kuhn & Jacob Molding & Tool Co., 1200 Southard Ave., Trenton 8, N.J.
Kurz Kasch, Inc., 1421 S Broadway, Dayton 1, Ohio
Kuss, R.L. & Co., Inc., 739 Foulke Ave., Findlay, Ohio
Kutztown Foundry & Machine Corp., Kutztown, Pa.
Kwikset Powdered Metal Products, 516 E Santa Ana St., Anaheim, Calif.

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L. & R. Mfg. Co., 577 Elm St., Kearny, N.J.
Laboratory Equipment Corp., Hilltop Rd. & Lakeview Ave., St. Joseph, Mich.
Laclede Steel Co., 1380 Arcade Bldg., St. Louis 1, Mo.
Laconia Malleable Iron Co., 71 Water St., Laconia, N.H.
Lacquer & Chemical Corp., 214 40th St., Brooklyn 32, N.Y.
Lacquer Products, Inc., 9001 Kinsman Rd., Cleveland 4, Ohio
Ladish Co., 5481 S Packard Ave., Cudahy, Wis.
La France Precision Casting Co., 29th & McKean St., Philadelphia 45, Pa.
Lake City Malleable Co., 5000 Lakeside Ave., Cleveland 14, Ohio
Lake Erie Foundry Co., 143 Fillmore Ave., Buffalo 10, N.Y.
Lake Mfg. Corp., 1070 East St., New Britain, Conn.
Lakeland Industries, Isle, Minn.
Lakeside Bronze, Inc., 90 Arthur St., Buffalo 7, N.Y.
Lakeside Malleable Casting Co., 1333 23rd St., Racine, Wis.
Lakewood Metal Products, Inc., 39 Cherry Ave., Waterbury 20, Conn.
Laminated Plastex Corp., 1427 W North St., Springfield, Ohio
Laminated Shim Co., 1600 Union St., Glenbrook, Conn.
Laminated Veneers Co., 102nd St. & 92nd Ave., Richmond Hill, N.Y.
Lamson Products Co., 1128 Poplar Pl., Seattle 44, Wash.
Lamson & Sessions Co., 5000 Tiedeman Rd., Cleveland 9, Ohio
Lamtex Industries, Inc., 66 Brooklyn Ave., Westbury, L.I., N.Y.
Lancaster Glass Corp., 220 W Main St., Lancaster, Ohio
Lancaster Malleable Castings Co., 1170 Lititz Ave., Lancaster, Pa.
Landau, J. & Co., Inc., Carlstadt, N.J.
Landers Frary & Clark, Republic Die Casting Div., Ft. Smith, Ark.
Lang-Scharmann & Co., 206 W 1st St., Marshfield, Wis.
Langsenkamp, F.H. Co., 229 E South St., Indianapolis, Ind.
Langsenkamp-Wheeler Brass Works, Inc., South & Harmon Sts., Indianapolis, Ind.
Lansdale Porcelain Enamel Corp., 5th & Iron, Lansdale, Pa.
Lansing Stamping Co., Box 838, 1167 S Pennsylvania Ave., Lansing 4, Mich.
La Porte Foundry Co., 301 Truesdell Ave., La Porte, Ind.
Larkin Specialty Mfg. Co., 915 Linden Ave., South San Francisco, Calif.
Larsen, W.O. Foundry Co., 799 Barchard, Grafton, Ohio
Larson, Charles E. & Sons, Inc., 2645-65 N Keeler Ave., Chicago 39, Ill.
Larson Tool & Stamping Co., Olive St., Attleboro, Mass.
La Salle Steel Co., P.O. Box 6800-A, Chicago 80, Ill.
Latrobe Die Casting Co., Latrobe, Pa.
Latrobe Steel Co., Latrobe, Pa.
Lattimer Foundry and Machine Co., Lattimer Mines, Pa.
Lattner Bros. Machining Co., 650 E Troy, Ferndale 20, Mich.
Latweitis, Ernest A., 102-09 Remsen Pl., Howard Beach 14, N.Y.
Lavelle Rubber Co., 424 N Wood St., Chicago 22, Ill.
Lavin, R. & Sons, Inc., 3426 S Kedzie Ave., Chicago 23, Ill.
Lawrence, L. Co., Inc., 292 Halsey St., Newark 2, N.J.
Lawrence Copper & Bronze Co., W New Castle St., Zilenpole, Pa.
Lawrence Laboratory, 1668 Euclid St., Santa Monica, Calif.
Lawrenceville Screw Co., 4920 Harrison St., Pittsburgh 1, Pa.
Lawson, F.H. Co., Evans & Whateley Sts., Cincinnati 4, Ohio
Lawton, C.A. Co., Broadway, DePere, Wis.
Laystrom Mfg. Co., 3900 W Palmer St., Chicago 47, Ill.
Leach & Garner Co., Industrial Div., Leach & Garner Bldg., Attleboro, Mass.
Leader Iron Works, Inc., 2108 N Jasper St., Decatur, Ill.
Leake Engineering Co., P.O. Box 715-MS, Monroe, Mich.
Lebanon Steel Foundry, 1st Ave. & E Lehmen St., Lebanon, Pa.
LeBaron, E.L. Foundry, Box 746, Brockton, Mass.
Lee Bros. Foundry Co., Inc., P.O. Box 231 Anniston, Ala.
Lee Rubber & Tire Corp., Hector St., Conshohocken, Pa.
Republic Rubber Div., Youngstown 1, Ohio
Leed, H.A. Co., 1685 Dixwell Ave., Hamden, Conn.
Leffingwell Chemical Co., P.O. Box 1187 Perry Annex–10523 So. Santa Gertrudes, Whittier, Calif.
Lehigh, Inc., 1500 Lehigh Dr., Easton, Pa.
Lehigh Foundries Div., 1500 Lehigh Dr., Easton 1, Pa.
Lehigh Structural Steel Co., Allentown, Pa.
Leitelt Bros., Inc., 7721-31 S Chicago Ave., Chicago 19, Ill.
Lenape Hydraulic Pressing & Forging Co. (Ad p 422) Box 536, West Chester, Pa.
Lester Castings Inc., Cannon & Aurora Rds., Bedford Heights, Ohio
LeTourneau, R. G., Inc., 2399 S MacArthur, Longview, Tex.
Letukas Foundry, Inc., Upland, Ind.
Levinson Steel Co., S 20th & Wharton St., Pittsburgh 3, Pa.
Lewco, 3901 Carew Tower, Cincinnati 2, Ohio
Lewis, G. B. Co. (Ad p 434) 4026 Montgomery St., Watertown, Wis.
Lewis, J.P. Co., Plastic Products Div., Beaver Falls, N.Y.
Lewis Bolt & Nut Co., 504 Malcolm Ave. SE, Minneapolis 14, Minn.
Lewis & Saunders, Lakeport, N.H.
Lewistown Foundry & Machine Co., 16 Elizabeth St., Lewistown, Pa.
Libbey-Owens-Ford Glass Co., Liberty Mirror Div., 851 3rd Ave., Brackenridge, Pa.
Liberty Foundry Co., 7600 Vulcan St., St. Louis 11, Mo.
Light Metals Corp., 1211 Monroe Ave. NW, Grand Rapids, Mich.
Light Metals, Inc., 1100 E 24th St., Indianapolis 5, Ind.
Lignum-Vitae Products Corp. (Ad p 414) 98 Boyd Ave., Jersey City 4, N.J.
Lincoln Electric Co., 22801 St. Clair Ave., Cleveland 17, Ohio
Lincoln Foundry Corp., 2525 E 49th St., Los Angeles 58, Calif.
Lincoln Iron Works, 255 West St., Rutland, Vt.
Lincoln Machine Parts Corp., 732 E 144th St., New York 54, N.Y.
Lincoln Mfg. Co., Inc., 2617 W Fletcher St., Chicago 18, Ill.
Lincoln Molded Plastics, Inc., Corwin & Clinton Sts., Circleville, Ohio
Lincoln Steel Corp., 315 W 9th St., Lincoln 1, Neb.
Lindell Drop Forge Co., 2830 S Logan Blvd., Lansing 3, Mich.
Linden & Co., 80 Baker St., Providence 5, R.I.
Linderme Tube Co., 1500 219th St., Cleveland 17, Ohio
Link-Belt Co., Dept. 61-MDE, 1700 Prudential Plaza, Chicago 1, Ill.
Linton Precision Casting Co., 917 N Nappanee St., Elkhart, Ind.
Litemetal Dicast, Inc., 1927 Wildwood Ave., Jackson, Mich.
Lithcote Corp., 5000 W Lake St., Melrose Park, Ill.
Lithium Corp. of America, Inc., 400 2nd Ave. S., Minneapolis 1, Minn.
Litho-Strip Corp., M. M. Young Div., 4800 S Kilbourn Ave., Chicago 32, Ill.
Little Foundries, Inc., 2431 Conners St., Port Huron, Mich.
Little Falls Alloys, Inc. (Ad p 426) 189 Caldwell Ave., Paterson, N.J.
Littleford Bros. Inc., 453 E Pearl St., Cincinnati 2, Ohio
Littlestown Hardware & Foundry Co., Inc., Charles St., Littlestown, Pa.
Livingston-Tyler Products, 501 N 5th St., Hamilton, Ohio
Lloyd & Scott Brass Foundry, Inc., 2206 Tatnall St., Wilmington 99, Del.
Lock Joint Tube Co., Inc., 1400 Riverside Dr., South Bend 24, Ind.
Locke Machine Co., Center St., Andover, Ohio
Lockhart Iron & Steel Co., River Ave., McKees Rocks, Pa.
Lockport Mfg. Co., 1102 Collins St., Joliet, Ill.
Lockport Steel Fabricators, Inc., P.O. Box 67, Lockport, Ill.
Lodge Mfg. Co., RR & 6th, South Pittsburg, Tenn.
Lodi Iron Works, Inc., 820 S Sacramento, Lodi, Calif.
Loeffler, J. M. Machine Co., Hwy. #1 & Robbins Ave., Penndel, Pa.
Lone Star Plastics Co., Inc., 124 Roberts Cutoff, Fort Worth, Tex.
Long Beach Iron Works, 2100 W Anaheim St., Long Beach 13, Calif.
Long Foundry Co., Hoquiam, Wash.
Lorain Automatic Screw Machine Co., Inc., 218 Connecticut, Lorain, Ohio
Lorain Brass Co., 639 Broadway, Lorain, Ohio
Loranger Mfg. Corp., 12-38 Clark St., Warren, Pa.
Lord Mfg. Co., Hughson Chemical Co. Div., Greengarden at 12th, Erie, Pa.
Los Angeles Galvanizing Co., Vernon Branch, P.O. Box 58411, Los Angeles 58, Calif.
Los Angeles Steel Casting Co., 6100 S Boyle Ave., Los Angeles 58, Calif.
Lowe Bros. Co., 424 E 3rd St., Dayton 2, Ohio
Lubenow, Arthur Co., 2015 S Kinnickinnic Ave., Milwaukee 7, Wis.
Lucas - Milhaupt Engineering Co. (Ad p 468) 5051 S Lake Dr., Cudahy, Wis.
Ludlow Plastics, 145 Rosemary St., Needham Heights 94, Mass.
Ludlow Valve Mfg. Co., Inc., Hudson River at Adams St., Troy, N.Y.
Lukens Steel Co., Coatesville, Pa.
Lumen Bearing Co., 197 Lathrop St., Buffalo 12, N.Y.
Luminous Resins, Inc., 166 W Washington St., Chicago 2, Ill.
Lundberg Screw Products Co., 2101 W Willow St., Lansing 4, Mich.
Lundquist Tool & Mfg. Co., Inc., 57 Jackson St., Worcester 8, Mass.
Lunn Laminates, Inc., Oakwood & W 11th Sts., Huntington Station, N.Y.
Lus-Trus Corp., 884 Railroad St., Ypsilanti, Mich.
Lux Clock Mfg. Co., Inc., 95 Johnson St., Waterbury 20, Conn.
Luzerne Rubber Co., Muirhead Ave., Trenton 7, N.J.
Lynchburg Foundry Co., Castings Div., Courtland Bldg., Lynchburg, Va.
Lyndon Machine Products Co., Inc., 18564 Fitzpatrick Ave., Detroit 28, Mich.
Lynn Casting Corp., 3014 Floyd St., Burbank, Calif.

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M & S Mfg. Co., 220 Main St., Hudson, Mich.
Maas & Waldstein Co., 2121 McCarter Hwy., Newark 4, N.J.
Macaulay, H.C. Foundry Co., 811 Carlton St., Berkeley 10, Calif.
MacDermid Inc., 526 Huntingdon Ave., Waterbury 20, Conn.
Machine Products Corp., 125 Hollier Ave., Dayton, Ohio
Machinery Forging Co., 5430 Hamilton Ave., Cleveland 14, Ohio
Machinery Products Corp., 2020 N Major Ave., Chicago 39, Ill.
Machinery Products Co. of Lancaster, 317 E Fulton St., Lancaster 11, Pa.
Mac-It Parts Co., 275 E Liberty St., Lancaster, Pa.
Mack Molding Co., Wayne, N.J.
MacKenzie-Walton Co., 478 Pawtucket Ave., Pawtucket, R.I.
MacLean-Fogg Lock Nut Co., 5535 N Wolcott St., Chicago 40, Ill.
Maco Industries Inc., 6200 S Ashland Ave., Chicago 36, Ill.
Madin Plastics Inc., 370 North Ave., Cranford, N.J.
Madison Foundry Co., 935 Addison Rd., Cleveland 3, Ohio
Madison Kipp Corp., 205 Waubesa St., Madison 10, Wis.
Magic Chemical Co., 121 Crescent St., Brockton 2, Mass.
Magic Iron Cement Co. Inc., 14215 Caine Ave., Cleveland 28, Ohio
Magline, Inc., 1960 Mercer, Pinconning, Mich.
Magna Mfg. Co., Inc., 4th Ave., Haskell, N.J.
Magnesium Elektron, Inc., 630 5th Ave., New York 20, N.Y.
Magnesium Products of Milwaukee, Inc., 740 N Plankinton Ave., Milwaukee 3, Wis.
Magnetic Core Corp., John & Lawrence Sts., Newburgh, N.Y.
Magnetic Powders, Inc., Fairview Ave., Johnsonburg, Pa.
Magnetic Stamping Co., Fairview Ave., Johnsonburg, Pa.
Magnode Products, Inc., P.O. Box 292, Trenton, Ohio
Magnolia Metal Co., 800 McCarter Hwy., Newark 4, N.J.
Magnuson Products Corp., 50 Court St., Brooklyn 1, N.Y.
Mahon, R.C. Co., 6565 E 8 Mile Rd., Detroit 34, Mich.
Main Screw Machine Products, Inc., 58 Lafayette St., Waterbury, Conn.
Malleable Iron Fittings Co., Branford, Conn.
Mallinckrodt Chemical Works, 2nd & Mallinckrodt Sts., St. Louis 7, Mo.
Mallory, P.R. & Co., Inc., 3033 E Washington St., Indianapolis 6, Ind.
Mallory, P.R. Plastics, Inc., 3670 Milwaukee Ave., Chicago 41, Ill.
Malone Bronze Powder Works, Inc., Malone, N.Y.
Malone Metal Powders, Inc., Rte. 202, Flemington, N.J.
Maloney, F.H. Co., 2301 Texas Ave., P.O. Box 1777, Houston 1, Tex.
Malvern Brick & Tile Co., P.O. Box 641, Malvern, Ark.
Manco Products, Inc., 2401 Schaefer Rd., Melvindale, Mich.
Manganese Steel Forge Co., Richmond St. & Castor Ave., Philadelphia 34, Pa.

Manhattan Adhesives Corp., 425 Greenpoint Ave., Brooklyn 22, N.Y.
Mannesmann-Easton Plastic Products Co., Inc., 900 Line St., Easton, Pa.
Manor Die Cast Corp., P.O. Box 386, Bedford, Ohio
Mansfield Brass & Aluminum Corp., 287 N Diamond St., Mansfield, Ohio
Mansol Ceramics Co., 140 Little St., Belleville 9, N.J.
Mantel Screw Products Co., 3200 W Vliet St., Milwaukee 8, Wis.
Manufacturers Corp., 104 Aundale Ave., Mansfield, Ohio
Manufacturers & Fabricators, Inc., Filbert St., Elyria, Ohio
Manufacturers Iron Foundry, Inc., 785 Union Ave., Bridgeport, Conn.
Manufacturers Service, Inc., 11440 Brookpark Rd., Cleveland 30, Ohio
Marblette Corp., 37-31 30th St., Long Island City 1, N.Y.
Markal Co., 3052 W Carroll Ave., Chicago 12, Ill.
Markel, L. Frank & Sons, School Lane, Norristown, Pa.
Marlane Development Co., Inc., 153 E 26th St., New York 10, N.Y.
Marquette Corp., Marquette Mfg. Co. Div., 207 E Hennepin Ave., Minneapolis 14, Minn.
Marquette Metal Products Co., 1145 Galewood Dr., Cleveland 10, Ohio
Marsco Mfg. Co., 2901 S Halsted St., Chicago 8, Ill.
Marshall Car Wheel & Foundry Co., Inc., 605 Greenwood Ave., Marshall, Tex.
Martin Rubber Co., Inc., Long Branch Ave., Long Branch, N.J.
Masco Screw Products Co., 12825 Ford Rd., Dearborn, Mich.
Masland Duraleather Co., Amber & Willard Sts., Philadelphia 34, Pa.
Mason Envelope Co., Inc., 536 Broadway, New York 12, N.Y.
Masonite Corp., 111 W Washington St., Chicago 2, Ill.
Massachusetts Screw Mfg. Co., 9 W 3rd St., South Boston 27, Mass.
Massillon Steel Casting Co., Box 380, Massillon, Ohio
Master Chrome Service, Inc., 5709 Herman Ave., Cleveland 2, Ohio
Matthiessen & Hegeler Zinc Co., 9th & Sterling Sts., La Salle, Ill.
May, Inc., 5803 Alice Rd., Houston 5, Tex.
Maynard Mfg. Co., 22755 Shakespeare Ave., East Detroit, Mich.
Mayon Plastics, 415 17th Ave. N, Hopkins, Minn.
Mayville Metal Products Co., 104 Highland St., Mayville, Wis.
Maywood Chemical Works, 111 W Hunter Ave., Maywood, N.J.
Maze, W.H. Co., 1207 Water St., Peru, Ill.
McCarter Iron Works, Inc., Norristown, Pa.
McCrady Refractories, Inc., P.O. Box 11566, Pittsburgh 38, Pa.

McDanel Refractory Porcelain Co. (Ad p 315)
510 9th Ave., Beaver Falls, Pa.

McDougall Butler Co., Inc., 2929 Main St., Buffalo 14, N.Y.
McDowell Mfg. Co., 301 Stanton Ave., Pittsburgh 9, Pa.
McDowell-Wellman Cos., 113 St. Clair Ave. NW, Cleveland 14, Ohio
McGean Chemical Co., 1040 Midland Bldg., Cleveland 15, Ohio
McGee Chemical Co., Inc., 8000 W Chester Pike, Upper Darby, Pa.
McGraw-Edison Co., 5201 W 65th St., Chicago, Ill.
Illinois Edison Porcelain Div., Macomb, Ill.
Line Material Industries Div., N Burson St., East Stroudsburg, Pa.
Mc Gregor-Michigan Corp., 9810 Rivard, Detroit 11, Mich.
McInnes Steel Co., 441 E Main St., Corry, Pa.
McKay Co., 481 McKay Bldg., Pittsburgh, Pa.
McKinney Mfg. Co., 1715 Liverpool St., Pittsburgh 33, Pa.
McLanahan & Stone Corp., 200 Wall St., Hollidaysburg, Pa.
McLouth Steel Corp., 300 S Livernois Ave., Detroit 17, Mich.
McMahon Bros. Machine Works, Inc., 3200 S 61st Court, Cicero 50, Ill.
McNally Pittsburg Mfg. Co., P.O. Drawer D., Pittsburg, Kan.
Meaden Screw Products Co., 3010 S Kilbourn Ave., Chicago 23, Ill.
Meadville Malleable Iron Co., Meadville, Pa.
Mearl Corp., 124 E 40th St., New York 16, N.Y.
Measuregraph Co., 4245 Forest Park Blvd., St. Louis 8, Mo.
Mechanical Art Works, Inc., 96-98 Monroe St., Newark 5, N.J.
Mechanical Felt & Textiles Co., 50 W 18th St., Weehawken, N.J.
Mechanical Leathers, Inc., 2284 E Butler St., Philadelphia 37, Pa.
Mechanical Plating Co., 1500-26 W Hubbard St., Chicago 22, Ill.
Mechanical Rubber Products Co., Warwick, N.Y.
Medico Industries, Inc., 11-13 Tompkins St., Pittston, Pa.

Meehanite Metal Corp. (Ad p 431)
714 North Ave., New Rochelle, N.Y.

Meeker Foundry Co., Newark 4, N.J.
Meier Brass & Aluminum Co., 1471 E Nine Mile Rd., Hazel Park, Mich.
Meier Screw Products & Mfg. Co., 19361 Sherwood Ave., Detroit, Mich.
Melco Wire Products, 4407 San Fernando Rd., Glendale 4, Calif.
Melling Forging Co., 1709 Thompson St., Lansing 3, Mich.
Melray Mfg. Co., 9511 W. River St., Schiller Park, Ill.
Merit Screw Machine Products Co., Inc., 4847 W Lake St., Chicago 44, Ill.
Merit Specialties Co., Inc., 203-205 E Davis St., St. Louis 11, Mo.
Merix Chemical Co., 2234 E 75th St., Chicago 49, Ill.
Merrimac Brass, 22 High St., Merrimac, Mass.
Merriman Bros., Inc., 185 Amory St., Boston 30, Mass.
Merz Machine & Tool Works, 920 N Main St., Crown Point, Ind.

Mesa Plastics Co. (Ad p 268)
12270 Nebraska Ave., Los Angeles 25, Calif.

Metal Carbides Corp., 107 E Indianola Ave., Youngstown 5, Ohio
Metal Coating Corp., 1215 W 37th St., Chicago 9, Ill.
Metal Finishers, Inc., 78 S Franklintown Rd., Baltimore 23, Md.
Metal Goods Corp., 8800 Page Blvd., St. Louis 14, Mo.
Metal Hydrides, Inc., 12 Congress St., Beverly, Mass.
Metal Parts & Stamping Co., 1120 Eastern Ave., Cincinnati, Ohio
Metal Powder Products, Inc., P.O. Box 189 M, Logan, Ohio
Metal Textile Corp., 647 E 1st Ave., Roselle, N.J.
Metal Trims, Inc., Livingston Rd., Jackson, Miss.

Metal & Thermit Corp. (Ad p 345)
Rahway, N.J.

Metal-Cladding, Inc., P.O. Box 544, North Tonawanda, N.Y.
Metallized Carbon Co., 19 S Water St., Ossining, N.Y.
Metallizing Co. of America, 3520 W Carroll Ave., Chicago 24, Ill.
Metallizing Co. of Los Angeles, Inc., 1233 S Boyle Ave., Los Angeles 23, Calif.
Metallurgical Products Co., 35th & Moore Sts., Philadelphia, Pa.
Metallo Gasket Co., 16 Bethany St., New Brunswick, N.J.
Metalplate Co., Inc., 757 North 44th St., Birmingham 6, Ala.
Metals and Residues, Inc., 65 Brown Ave., Springfield, N.J.
Metals Engineering Corp., Forest Hills Dr., Greenville, Tenn.
Metalweld, Inc., Protective Coating Div., Scotts Lane & Abbottsford Ave., Philadelphia, Pa.
Metaplast Process, Inc., 34-51 56th St., Woodside, N.Y.
Metco, Inc., 1101 Prospect Ave., Westbury, N.Y.
Met-L-Wood Corp., 6755 W 65th St., Chicago 38, Ill.
Metropolitan Iron Foundry, 890 Metropolitan Ave., Brooklyn 11, N.Y.
Metz Refining Co., 369 Mulberry St., Newark 2, N.J.
Meyer, J. & Sons, Inc., 4321 N 4th St., Philadelphia 40, Pa.
Mica Corp., 4031 Elenda St., Culver City, Calif.
Mica Fabricating Co., 53 Central Ave., Rochelle Park, N.J.
Micacraft Products, Inc., 701 McCarter Hwy., Newark, N.J.
Michelman Chemicals, Inc., 6316 Wiehee Rd., Cincinnati, Ohio
Michigan Chemical Corp., Rare Earths & Thorium Div., St. Louis, Mich.
Michigan Chrome & Chemical Co., 8615 Grinnell Ave., Detroit 13, Mich.
Michigan Leather Products Co., 6307 E Lafayette Ave., Detroit 7, Mich.
Michigan Pipe Co., Saran Lined Pipe Co. Div., 2415 Burdette Ave., Ferndale 20, Mich.
Michigan Plastic Products, Inc., Robbins Rd., Grand Haven, Mich.
Michigan Seamless Tube Co., South Lyon, Mich.
Michigan Wire Cloth Co., 2100 Howard St., Detroit 16, Mich.
Mico Corp., 4031 Elenda, Culver City, Calif.
Micro Metallic Corp., 30 Sea Cliff Ave., Glen Cove, N.Y.
Micro Products Corp., 4116-18 Olive St., St. Louis 8, Mo.
Micrometals, 72 E Montecito Ave., Sierra Madre, Calif.
Midland Adhesive & Chemical Corp., 2600 Goodrich, Ferndale 20, Mich.
Midland Industrial Finishes Co., E Water St., Waukegan, Ill.
Midland Pipe & Supply Co., 2829 S 61st St., Cicero 50, Ill.
Midland Screw Corp., 3638 S Kedzie Ave., Chicago 32, Ill.
Mid-States Rubber Products, Inc., 1230 Race St., Princeton, Ind.
Mid-States Steel & Wire Co., Crawfordsville, Ind.
Midvale-Heppenstall Co., Nicetown, Philadelphia 40, Pa.
Midwest Molding & Mfg. Co., Gurnee, Ill.
Midwest Piping Co., Inc., 2nd & Barry Sts., St. Louis 4, Mich.
Midwest Plastic Products Co., 1801 Chicago Rd., Chicago Heights, Ill.
Midwest Precision Castings Co., 1870-903 Quincy Ave., Cleveland 6, Ohio
Midwest Rubber Co., 14273 E 9 Mile Rd., East Detroit, Mich.
Mid-West Screw Products Co., 3662 Park Ave., St. Louis 10, Mo.
Midwest Screw Products, Inc., 1641 Colt Ave., East Cleveland 12, Ohio
Midwest Sintered Products Corp., 13606 S Halsted St., Chicago 27, Ill.
Midwest Stamping & Mfg. Co., Kramer Rd., Bowling Green, Ohio
Mid-West Wire Products Co., Inc., 2555 Fenkell Ave., Detroit 38, Mich.
Midwestern Foundries, Inc., 614 E Quincy, Garrett, Ind.
Milford Automatics, Inc., 1553 Boston Post Rd., Milford 15, Conn.
Milford Rivet & Machine Co., Milford, Conn.
Milled Screw Product Co., 2016-2026 W Lake St., Chicago 12, Ill.
Miller Co., 99 Center St., Meriden, Conn.
Miller-Stephenson Chemical Co., Inc., 18 Marshall St., South Norwalk, Conn.
Millers' Brass Fitting Co., Inc., 30 Main St., Brooklyn 1, N.Y.
Milwaukee Aluminum & Brass Foundry, 643 S 2nd St., Milwaukee 4, Wis.
Milwaukee Die Casting Co., 4134 N Holton St., Milwaukee 12, Wis.
Milwaukee Forge & Machine Co., 1532 E Oklahoma Ave., Milwaukee 7, Wis.
Milwaukee Machine Products Co., 3889 N 1st St., Milwaukee 12, Wis.
Milwaukee Malleable & Grey Iron Works, 2773 S 29th St., Milwaukee 46, Wis.
Milwaukee Stamping Co., 800-S 72nd St., Milwaukee 14, Wis.
Milwaukee Valve Co., 2375 S. Burrell St., Milwaukee 7, Wis.
Minimax Co., 5905 N Clark St., Chicago 26, Ill.
Minneapolis Electric Steel Castings Co., 3800 NE 5th St., Minneapolis 21, Minn.
Minneapolis Plastic Molders, Inc., 5742 Nicollet Ave. S, Minneapolis 19, Minn.
Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.

Adhesives, Coatings & Sealers Div. (Ad p 466)
411 Piquette Ave., Detroit 2, Mich.

Chemical Div., 900 Bush Ave., St. Paul 16, Minn.
Irvington Varnish & Insulator Div., Irvington, N.J.
Mica Insulator Div., 797 Broadway, Schenectady 1, N.Y.
Reinforced Plastics Div., 900 Bush Ave., St. Paul 6, Minn.
Zenith Plastics Co. Div., Box 91, Gardena, Calif.
Minnesota Paints, Inc., 1101 S 3rd St., Minneapolis 15, Minn.
Minnesota Plastics Corp., 45 E Maryland Ave., St. Paul 3, Minn.
Minnesota Rubber Co., 3630 Wooddale Ave., Minneapolis 16, Minn.
Miracle Adhesives Corp., 250 Pettit Ave., Bellmore, L.I., N.Y.
Mirra Cote Co., Inc., P.O. Box 158, 120 Standard St., El Segundo, Calif.
Mirro Aluminum Co., 1512 Washington St., Manitowoc, Wis.

Misco Precision Casting Co. (Ad p 419)
116 W Gibbs, Whitehall, Mich.

Misner Corp., 940 N 23rd St., Omaha 2, Neb.
Missouri Boiler & Sheet Works, 23rd & Papin Sts., St. Louis 3, Mo.
Missouri Diecasting Co., 1411 N 17, St. Louis 6, Mo.
Missouri Rolling Mill Corp., 6800 Manchester Ave., St. Louis 10, Miss.
Missouri Steel Castings Co., 905 E 3rd St., Joplin, Mo.
Mitchell & Scott Machine Co., Inc., 1841 Ludlow Ave., Indianapolis 7, Ind.
Mitchell-Bradford Chemical Co., Wampus Lane, Milford, Conn.
Mobay Chemical Co., Penn Lincoln Parkway W, Pittsburgh 5, Pa.

In contacting suppliers, please mention the Materials Selector Issue

Mobile Paint Mfg. Co., Inc., P.O. Box 1686, Mobile, Ala.

Moccasin Bushing Co., 2000 Chestnut St., Chattanooga 8, Tenn.

Moczik Tool & Die Works, 9511 Grinnell, Detroit 13, Mich.

Model Brass Co., Inc., 232-40 E Decatur St., Decatur, Ill.

Modern Brass Foundry & Mfg. Co., 157 Thurman St., Columbus 6, Ohio

Modern Plastics Corp., 489 N Shore Dr., Benton Harbor, Mich.

Modern Plating Corp., 121-129 S Hancock Ave., Freeport, Ill.

Modern Screw Products Co., 2307 N 9th St., St. Louis 6, Mo.

Modiglass Fibers, Inc., P.O. Box 86, Bremen, Ohio

Mohawk Foundries, Inc., 55 1st Ave., Berea, Ohio

Moldcast Products, Inc., Pacific St., Newark 5, N.J.

Molded Fiber Glass Co., 4401 Benefit Ave., Ashtabula, Ohio

Moldex, 747 5th Ave., New York 22, N.Y.

Molecular Dielectrics, Inc., 101 Clifton Blvd., Clifton, N.J.

Moline Iron Works, 130 2nd, Moline, Ill.

Moline Malleable Iron Co., St. Charles 5, Ill.

Moltrup Steel Products Co., 2nd Ave. & 14th St., Beaver Falls, Pa.

Molybdenum Corp. of America, Washington, Pa.

Monarch Aluminum Mfg. Co., 9205 Detroit Ave., Cleveland 2, Ohio

Monarch Products Co., Leake Stamping Div., 1259 E 1st St., Monroe, Mich.

Monarch Tool & Mfg. Co., 105 E 4th St., Covington, Ky.

Mono-Seal Products, 427 Broadway, Everett 49, Mass.

Mono-Sol Corp., 407 County Line Rd., Gary, Ind.

Monroe Steel Castings Co., 917 W Front, Monroe, Mich.

Monsanto Chemical Co., 600 Monsanto Ave., Springfield, Mass.

Inorganic Chemicals Div., 800 N Lindbergh Blvd., St. Louis 66, Mo.

Organic Chemicals Div., Lindbergh & Olive St. Rd., St. Louis 24, Mo.

Plastics Div. (Ad pp 212-213)
Springfield 2, Mass.

Montague Machine Co., 15th St., Turners Falls, Mass.

Monteath, J.H. Co., 2504 Park Ave., New York, N.Y.

Moody Machine Products Co., Inc., 42 Dudley St., Providence 5, R.I.

Moore, George W., Inc., 100 Beaver St., Waltham 54, Mass.

Moore, Samuel & Co., Mantua, Ohio

Moore Dry Dock Co., Adeline St., Oakland 23, Calif.

Morganite, Inc., 3302 48th Ave., Long Island City 1, N.Y.

Morningstar-Paisley, Inc., 630 W 51st St., New York 19, N.Y.

Morrell, George Corp., P.O. Box 155, Muskegon Heights, Mich.

Morrison Steel Products, Inc., 601 Amherst St., Buffalo 7, N.Y.

Morrisville Foundry Co., Inc., Morrisville, Vt.

Morse, Fred W. Co., 309 S Main St., Providence 3, R.I.

Morton Mfg. Co., 5125 W Lake St., Chicago 44, Ill.

Mosinee Paper Mills Co., Mosinee, Wis.

Mott Metallurgical Corp., 272 Huyshope Ave., Hartford, Conn.

Mount Vernon Die Casting Corp., Southfield Ave., Stamford, Conn.

Mount Vernon Furnace & Mfg. Co., Mount Vernon, Ill.

Moxness Products, Inc. (Ad p 302)
1914 Indiana St., Racine, Wis.

Muehlstein, H. & Co., Inc., 60 E 42nd St., New York 17, N.Y.

Mueller Brass Co. (Ad p 404)
1925 Lapeer Ave., Port Huron, Mich.

Mueller Machine Products, Inc., 3807 S Packard Ave., Milwaukee 7, Wis.

Muncie Malleable Foundry Co., E Highland Ave., Muncie, Ind.

Muncie Metal Spinning, Inc., 1012 E 20th St., Muncie, Ind.

Mundt, Charles & Sons, 53 Fairmount Ave., Jersey City 4, N.J.

Murray, A.B. Co., Inc., P.O. Box 476, Elizabeth, N.J.

Murray Tube Works, Inc., P.O. Box 476, Elizabeth, N.J.

Muskegon Piston Ring Co., Sparta Foundry Div., Sparta, Mich.

Mycalex Corp. of America (Ad p 320)
125 Clifton Blvd., Clifton, N.J.

Synthetic Mica Co. Div., 20 Passaic Ave., Caldwell, N.J.

Mystik Adhesive Products, Inc., 2635 N Kildare Ave., Chicago 39, Ill.

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Nalge Co., Inc., P.O. Box 365, Rochester 2, N.Y.

Napoleon Products Co., 410 Filmore St., Napoleon, Ohio

Narmco Industries, Inc., Narmco Materials Div., 600 Victoria St., Costa Mesa, Calif.

Narragansett Boiler Works, Inc., 614 S Main St., Providence 3, R.I.

National Acme Co., 170 E 131st St., Cleveland 8, Ohio

National Aluminum Co., 1133 Alum Creek Dr., Columbus 9, Ohio

National Aluminum Co., Inc., 1912 Edgewood Ave., Racine, Wis.

National Aluminum & Brass Foundry, Inc., P.O. Box 179, Independence, Mo.

National Aluminum Mfg. Co., 720 Park Ave., Peoria, Ill.

National Beryllia Corp., 4501 Dell Ave., North Bergen, N.J.

National Brass Works, Inc., 2140 E 25th St., Los Angeles 58, Calif.

National Casein Co., 601 W 80th St., Chicago 20, Ill.

National Copper & Smelting Co., 1862 E 123rd St., Cleveland 6, Ohio

National Die Casting Co., 3635 W Touhy Ave., Chicago 45, Ill.

National Distillers & Chemical Corp., U. S. Industrial Chemicals Co. Div., 99 Park Ave., New York 16, N.Y.

National Felt Co., 76 Summer St., Boston 10, Mass.

National Forge & Ordnance Co., Irvine, Warren County, Pa.

National Galvanizing Co., Neville Island, Pittsburgh 25, Pa.

National Gasket & Washer Mfg. Co., Inc., 124 E 25th St., New York 10, N.Y.

National Glaco Chemical Corp., Industrial Coatings Div., 1949 N Cicero Ave., Chicago 39, Ill.

National Grey Iron Foundry, Belvidere, Ill.

National Impacted Metal Corp., Box 726, New Albany, Miss.

National Lead Co., 111 Broadway, New York 6, N.Y.

Doehler-Jarvis Div., 1945 Smead Ave., Toledo, Ohio

Goldsmith Bros. Div., 111 N Wabash Ave., Chicago 2, Ill.

Titanium Alloy Mfg. Div., 2950 Hyde Park Blvd., Niagara Falls, N.Y.

Zirconium Metals Corp of America Sub. (Ad p 409)
111 Broadway, New York 6, N.Y.

National Lead Construction Co., Inc., 2810 E Allegheny Ave., Philadelphia 34, Pa.

National Lock Co., 1902 7th St., Rockford, Ill.

Fastener Div., 4500 Kishwaukee, Rockford, Ill.

National Lock Washer Co., 40 Hermon St., Newark 5, N.J.

National Machine Products Co., 44225 Utica Rd., Utica, Mich.

National Malleable & Steel Castings Co., 10600 Quincy Ave., Cleveland 6, Ohio

National Mfg. Corp., 153 Fillmore Ave., Tonawanda, N.Y.

National Metal Products Co., 2 Gateway Center, Pittsburgh 22, Pa.

National Molded Products, Inc., 40 St. Marys St., St. Marys, Pa.

National Moldite Co., 250 South St., Newark 5, N.J.

National Paint & Manganese Co., Lynchburg, Va.

National Research Corp., 70 Memorial Dr., Cambridge 42, Mass.

National Screw & Mfg. Co., 2440 E 75th St., Cleveland 4, Ohio

National Starch & Chemical Corp., Structural Products Div., 750 3rd Ave., New York 17, N.Y.

National Steel Corp., Grant Bldg., Pittsburgh, Pa.

Enamelstrip Corp. Sub., 20th & Hamilton Sts., Allentown, Pa.

Great Lakes Steel Corp. Div., Detroit 29, Mich.

Weirton Steel Co. Div., Weirton, W. Va.

National Steel & Shipbuilding Corp., Harbor Dr. & 28th St., San Diego 12, Calif.

National Tank Co., Box 1710, Tulsa, Okla.

National Vulcanized Fibre Co., Box 311, Wilmington 99, Del.

National-Standard Co., 601 N 8th St., Niles, Mich.

Athenia Steel Div., Clifton Ave., Clifton, N.J.

Cross Perforated Metals Plant, Carbondale, Pa.

Reynolds Div., 809 E 2nd St., Dixon, Ill.

Worcester Wire Works Div., 70 James St., Worcester, Mass.

National-U. S. Radiator Corp., Plastic Metals Div., 4459 Bridge St., Johnstown, Pa.

Neenah Foundry Co., Winneconne Ave., Neenah, Wis.

Neilson Chemical Co., 2300 Balmoral, Detroit (Ferndale) 20, Mich.

Nesbitt Industries, Inc., 1823 Milwaukee Ave., Chicago 47, Ill.

Nesor Alloy Products Co., 666 Passaic Ave., West Caldwell, N.J.

New Britain Machine Co., South St., New Britain, Conn.

New England Brass Co., 16 Park St., Taunton, Mass.

New England Die Casting Co., 445 Front Ave., West Haven, Conn.

New England Electrical Works, Inc., 365 Main St., Lisbon, N.H.

New England Laminates Co., P.O. Box 43, 481 Canal St., Stamford, Conn.

New England Smelting Works, Inc., 502 Union St., West Springfield, Mass.

New Haven Copper Co., Main St., Seymour, Conn.

New Haven Screw Machine Products, Inc., 561 Boston Post Rd., Milford, Conn.

New Jersey Aluminum Extrusion Co., Inc., Jersey Ave., New Brunswick, N.J.

New Jersey Metals Co., 712 Rockefeller St., Elizabeth 2, N.J.

New Jersey Zinc Co. (Ad pp 406-407)
160 Front St., New York 38, N.Y.

New Products Corp., 448 North Shore Ave., Benton Harbor, Mich.

New York Air Brake Co., Kinney Vacuum Div., 3529 Washington St., Boston 30, Mass.

New York Iron Roofing & Corrugating Co., Inc., 94 1st St., Jersey City 2, N. J.

Newage Industries, Inc., 222 York Rd., Jenkintown 3, Pa.

Newark Wire Cloth Co. (Ad p 396)
351 Verona Ave., Newark 4, N.J.

Newman Bros., Inc., 670 W 4th St., Cincinnati, Ohio

Newman-Crosby Steel Co., Deane St., Pawtucket, R.I.

Newport Steel Corp., 9th & Thomas Sts., Newport, Ky.

Newth Rubber Co., County Rd., Barrington, R.I.

Newton-New Haven Co., 680 3rd Ave., West Haven, Conn.

Newtown Mfg. Co., Newtown, Conn.

Ney, J.M. Co., Industrial Div., P.O. Box 990, Hartford 1, Conn.

Nichols, L.O. & Son Mfg. Co., 1625 Locust St., Kansas City 8, Mo.

Nichols Wire & Aluminum Co., 1725 Rockingham Rd., Davenport, Iowa

Nicolet Industries, Inc., 70 Pine St., New York 5, N.Y.

Nicoud Mfg. Co., 3220 Grand Ave., Chicago 51, Ill.

Nigg Engineering Corp., 545 N 2nd Ave., Covina, Calif.

Nikoh Tube Co., 5000 S Whipple St., Chicago 32, Ill.

Nikolas, G.J. & Co., Inc., 2890 Washington Blvd., Bellwood, Ill.

Nilsen Mfg. Co., Electronicast Div., 21 N Church St., Addison, Ill.

Nippert Electric Products Co., 1759 W Mound St., Columbus 23, Ohio

Nixon-Baldwin Chemicals, Inc., Nixon, N.J.

Noble & Wood Machine Co., 1st St., Hoosick Falls, N.Y.

Noera Mfg. Co., 236 Grand St., Waterbury 20, Conn.

Noland Tank & Galvanizing Co., 705 Merritt Ave., Nashville 4, Tenn.

Nolte Screw Machine Products, Inc., 5095 Crookshank Rd., Cincinnati, 38, Ohio

Nopco Chemical Co., 1st & Essex Sts., Harrison, N.J.

Plastics Div., 175 Schuyler Ave., North Arlington, N.J.

Norcross, C.S. & Sons Co., Dean & Davis Sts., Bushnell, Ill.

Norgren-Stemac, Inc., 5400 S Delaware, Littleton, Ohio

Norrich Plastics Corp., 107-109 W 18th St., New York, N.Y.

Screw Machine Products Div., 107-109 W 18th St., New York, N.Y.

North American Asbestos Corp., Board of Trade Bldg., Chicago 4, Ill.

North American Aviation, Inc., Navan Products, Inc. Sub., 900 N Sepulveda, El Segundo, Calif.

North American Phillips Co., Inc., Elmet Div., Lewiston, Me.

North American Refractories Co., 1012 National City-E 6th Bldg., Cleveland 14, Ohio

North & Judd Mfg. Co., Wilcox-Crittenden Div., Middletown, Conn.

Northern Malleable Iron Co., 867 Forest St., St. Paul 6, Minn.

Northern Plastics Corp., 2nd & Market St., La Crosse, Wis.

Northwest Automatic Products Corp., 1770 Linden Ave., Minneapolis 3, Minn.

Northwest Chemical Co., 9310 Roselawn Ave., Detroit 4, Mich.

Northwest Plastics Industries, Inc., 2040 15th Ave. W, Seattle 99, Wash.

Northwestern Steel & Wire Co., Ave. B & Wallace St., Sterling, Ill.

Norton Co. (Ad p 347)
New Bond St., Worcester 6, Mass.

Norwalk Powdered Metals, Inc., P.O. Box 271, Muller Park, Norwalk, Conn.

Norwich Leather Co., 685 N Main St., Norwich, Conn.

Nosco Plastics Co., 17th & Gasgo, Erie, Pa.

Novamont Corp., 2 B'way, New York 4, N.Y.

Nuclear Corp. of America, Research Chemicals Div., Box 431, Burbank, Calif.
Nuclear Materials & Equipment Corp., Warren Ave., Apollo, Pa.
Nuclear Metals, Inc., Concord, Mass.
Nukem Products Corp., 111 Colgate Ave., Buffalo 20, N.Y.
Nutmeg Crucible Steel Co., Elm & Harbor Sts., Branford, Conn.
Nutmeg Screw Machine Products Co., Wolcott Rd., Wolcott, Conn.
Nutt-Shel Co., Inc., 2701 S Harbor Blvd., Santa Ana, Calif.
Nylok Corp., 611 Industrial Ave., Paramus, N.J.
Nylok-Detroit, 1893 Barrett, Troy, Mich.
Nylon Molded Products Corp., Garrettsville, Ohio
Nyloncraft, Inc., 218 McKinley Hwy. W, Mishawaka, Ind.

O

Oak Hill Foundry & Machine Works, Box 278, Oak Hill, Ohio
Oakes Bronze & Aluminum Co., Bronze Rd., Warren, Ohio
Oakite Products, Inc. (Ad p 354)
19 Rector St., New York 6, N.Y.
Oakland Foundry & Machine Co., 607-621 Woodward Ave., Rochester, Mich.
Oatey, L. R. Co., 4700 W 160th St., Cleveland 35, Ohio
Octagon Process, Inc., 69 Bank St., Staten Island 1, N.Y.
Ohio Adhesives Corp., P.O. Box 466, New Philadelphia, Ohio
Ohio Carbon Co. (Ad p 318)
12508 Berea Rd., Cleveland 11, Ohio
Ohio Forge & Machine Corp., 3010 Woodhill Rd., Cleveland 4, Ohio
Ohio Metal Products Co., 35 N Bates St., Dayton 2, Ohio
Ohio Nut & Bolt Co., 33 1st Ave., Berea, Ohio
Ohio Nut & Washer Co., Box 66, Mingo Junction, Ohio
Ohio Precision Castings, Inc., 109 Webb St., Dayton 3, Ohio
Ohio Rubber Co., 301 Ben Hur Ave., Willoughby, Ohio
Ohio Screw Products, Inc., 818 West St., Elyria, Ohio
Ohio Steel Foundry Co., 1075 James St., Springfield, Ohio
Oil City Iron Works, P.O. Drawer 615, Corsicana, Tex.
Olderman Mfg. Corp., P.O. Box 917, Bridgeport, Conn.
Olds Alloys Co., 5601 E Imperial Hwy., South Gate, Calif.
Olean Electro Plating Co., 890 N 4th St., Olean, N.Y.
Olin Mathieson Chemical Corp., 460 Park Ave., New York 22, N.Y.
Metals Div. (Ad p 149)
400 Park Ave., New York 22, N.Y.
Packaging Div., 655 Madison Ave., New York 21, N.Y.
Olsen Mfg. Co., 100 Prescott St., Worcester 5, Mass.
Olympic Plastics Co., Inc., 3471 S La Cienega Blvd., Los Angeles 16, Calif.
Olympic Steel Works, 151 Horton St., Seattle 4, Wash.
Omaha Steel Works, 609 S 48th St., Omaha 6, Neb.
Omni Products Corp., 460 4th Ave., New York 16, N.Y.
Omni-Metal Castings, Inc., 195 11th St., Brooklyn 15, N.Y.
Optical Coating Laboratory, Inc., 2789 Giffen Ave., Santa Rosa, Calif.
Oregon Brass Works, 1127 SE 10th Ave., Portland 14, Ore.
Oregon Metallurgical Corp., P.O. Box 484, Albany, Ore.
Ormand Mfg. Co., Inc., 3325 Hudson Ave., Union City, N.J.
Ostby & Barton Co., Flightex Fabrics, Inc., 148 W River St., Providence 4, R.I.
O'Sullivan Rubber Corp., Box 603, Valley Pike St., Winchester, Va.
Plastics Div. (Ad p 215)
P.O. Box 603, Winchester, Pa.
Ottawa Steel Products, Inc., 745 Woodlawn Ave., Grand Haven, Mich.
Overmyer Mould Co., Inc., N Main St., Winchester, Ind.
Owen Pattern Foundry & Mfg. Co., Inc., 710 W 22nd St., Norfolk 10, Va.
Owens Plastics Co., 1514 Crystal, Kansas City 26, Mo.
Owens-Corning Fiberglas Corp., 608 Madison Ave., Toledo 3, Ohio
Owens-Illinois Glass Co., Toledo, Ohio
Closure & Plastics Div., P.O. Box 1035, Toledo 1, Ohio
Kimble Glass Co. Sub., P.O. Box 1035, Telodo 1, Ohio
Paper Products Div., P.O. Box 1035, Toledo 1, Ohio

P

Pabst Engineering Equipment Co., Inc., 676 Pennsylvania Ave., Elizabeth 3, N.J.
Pacific Brass Foundry of San Francisco, 251 2nd St., San Francisco 5, Calif.
Pacific Coast Foil Co., 500 Sansome St., San Francisco, Calif.
Pacific Foundry and Metallurgy Co., 3100 19th St., San Francisco, Calif.
Pacific Molded Products Corp., 905 E 59th St., Los Angeles 1, Calif.
Pacific Screw Products Co., 990 Linden Ave., South San Francisco, Calif.
Pacific Sintered Metals Co., 8333 Hindry Ave., Los Angeles 45, Calif.
Pacific States Steel Corp., Niles, Calif.
Pacific Tube Co., 5710 Smithway St., Los Angeles 22, Calif.
Paese Rubber Co., Inc., 225 W Lake St., Ravenna, Ohio
Page Belting Co., Concord, N.H.
Palmyra Foundry Co., Inc., Palmyra, N.J.
Pam-Pro Plastics, 1075 O'Brien Dr., Menlo Park, Calif.
Pan-American Metal Products Co., Inc., 491 NW 71st St., Miami 38, Fla.
Panther Chemical Corp., P.O. Box 711, Ft. Worth, Texas
Paragon Die Casting Co., 5851 W Dickens Ave., Chicago 39, Ill.
Paragon Spring Co., 4613-17 W Fulton St., Chicago 44, Ill.
Paramount Die Casting Co., St. Joseph, Mich.
Paramount Paint & Lacquer Co., 3411 E 15th St., Los Angeles 23, Calif.
Park Drop Forge Co., 777 E 79th St., Cleveland 3, Ohio
Parker, Charles Co., Hanover St., Meriden, Conn.
Parker Appliance Co., Rubber Products Div., 17325 Euclid Ave., Cleveland 12, Ohio
Parker & Harper Mfg. Co., 119 Dewey St., Worcester 10, Mass.
Parker Metal Goods Co., 85 Prescott St., Worcester, Mass.
Parker Paint Mfg. Corp., Locust & Poplar Sts., Valparaiso, Ind.
Parker Rust Proof Co. (Ad p 353)
2177 E Milwaukee, Detroit 11, Mich.
Parker, Stearns & Co., Inc., 300 Sheffield Ave., Brooklyn 7, N.Y
Parker White Metal Co., 2153 McKinley Ave., Erie, Pa.
Parker-Hannifin Corp., Parker Seal Co. Div., 10567 W Jefferson Blvd., Culver City, Calif.
Parker-Street Castings Co., Broadway & Chaincraft Rd., Cleveland 25, Ohio
Parkwood Laminates, Inc., 24 Water St., Wakefield, Mass.
Patterson Foundry & Machine Co., 41 Henene St., East Liverpool, Ohio
Pattin Mfg. Co., Box 527, Marietta, Ohio
Paulson, Thomas & Son, Inc., 450 Union St., Brooklyn 31, N.Y
Pawling Rubber Corp., Pawling, N.Y.
Payne, F.S. Co., 75 Richdale Ave., Cambridge 40, Mass.
Peasley Products, Inc., 993 Honeyspot Rd., Stratford, Conn.
Peck Spring Co., Whiting St., Plainville, Conn.
Pecora Inc., 300-400 W Sedgley Ave., Philadelphia 40, Pa.
Pee Wee Molding Corp., 1720 Atlantic Ave., Brooklyn 13, N.Y.
Peerless Alloy Co., 1445 Osage St., Denver 4, Colo.
Peerless Automatic Machine Co., 1970 W 77th St., Cleveland 2, Ohio
Peerless Industries, Inc., P.O. Box 318, Plymouth, Mich.
Peerless Products Industries, 812-14-16 N Pulaski Rd., Chicago 51, Ill.
Peerless Wire Goods Co., Inc., 2703 Ferry St., LaFayette, Ind.
Pelron Corp., 7847 W 47th St., Lyons, Ill.
Pelton Steel Casting Co., 148 W Dewey Pl., Milwaukee 7, Wis.
Pemco Corp., Eastern & Pemco Aves., Baltimore, Md.
Pemco Wheel Co., 1872 Ravine Rd., Kalamazoo, Mich.
Penberthy Instrument Co., 4301 6th Ave. S, Seattle 8, Wash.
Pencoyd Steel & Forge Corp., 3720-40 Main St., Philadelphia 27, Pa.
Peninsular Steel Co., P.O. Box 3853, Parkgrove Sta., Detroit 5, Mich.
Penn Brass & Copper Co., 3837 W 20th St., Erie, Pa.
Penn Engineering & Mfg. Corp., Box 311, Doylestown, Pa.
Penn Fibre & Specialty Co., Inc., 2024 E Westmoreland St., Philadelphia 34, Pa.
Penn Metal Co., Inc., P.O. Box 1400, Parkersburg, W. Va.
Penn Metal Co., Inc., 40 Central St., Boston 9, Mass.
Penn Steel Castings Co., Front & Penn Sts., Chester, Pa.
Pennsalt Chemicals Corp. (Ad p 223)
3 Penn Center, Philadelphia 2, Pa.
Pennsylvania Engineering Corp., P.O. Box 311, New Castle 17, Pa.
Pennsylvania Fluorocarbon Co., Inc., 1115 N 38th St., Philadelphia 4, Pa.
Pennsylvania Malleable Iron Corp., 712 S Prince St., Lancaster, Pa.
Peerod, Floyd & Sons Tool & Engineering Corp., 1208 W 2nd St., Muncie, Ind.
Peoria Malleable Casting Co., 2800 N Adams St., Peoria 1, Ill.
Peoria Plastic Co., East Peoria, Ill.
Pequonnock Foundry, Inc., 335 5th St., Bridgeport, Conn.
Pequot Wire Cloth Co., 35 Hoyt, Norwalk, Conn.
Perfect Circle Corp., 552 S Washington, Hagerstown, Ind.
Perfecto Cast, 5660 Kearney Villa Rd., San Diego 11, Calif.
Perfex Plastics, Inc., 2632 S Dearborn, Chicago 16, Ill.
Perforating Industries, Inc. (Ad p 422)
606 Commerce Rd., Linden, N.J.
Perkins, Henry Co., Broad St., Bridgewater, Mass.
Permacel, U. S. Hwy. #1, New Brunswick, N.J.
Permali, Inc. (Ad p 414)
Box 718, Mount Pleasant, Pa.
Permaspray Mfg. Co., 1220 Polk, Houston, Tex.
Permold Co., 1250 W Liberty St., Medina, Ohio
Perrin, Edward C. Co., 3rd & Grant Sts., Camden 2, N.J.
Perry Fay Co., 200 Perry Court, Elyria, Ohio
Perry Plastics, Inc., 3409 W 14th St., Erie, Pa.
Perry-Austen Mfg. Co., 250 Parkinson Ave., Staten Island 5, N.Y.
Peterson, D. J. Co., Sheboygan, Wis.
Peterson Products Corp., 4848 N River Rd., Schiller Park, Ill.
Pettibone Mulliken Corp., 4700 W Division St., Chicago 51, Ill.
Pfaudler Co., 1000 West Ave., Rochester 3, N.Y.
Pfister Tubing Corp., 54 W Allendale Ave., Allendale, N.J.
Phelps Dodge Copper Products Corp., 300 Park Ave., New York 22, N.Y.
Phelps Dodge Refining Corp., 40 Wall St., New York, N.Y.
Pheoll Mfg. Co., Inc., 5700 W Roosevelt Rd., Chicago 50, Ill.
Philadelphia Asbestos Corp., 2010 N 10th St., Philadelphia 22, Pa.
Philadelphia Bronze & Brass Corp., 22nd & Masters Sts., Philadelphia 22, Pa.
Philadelphia Enameling Works, Inc., 254 N 13th St., Philadelphia 7, Pa.
Philadelphia Steel & Wire Corp., Penn St. & Belfield Ave., Philadelphia 44, Pa.
Philco Corp., Dexter Foundry Div., 501 N 8th St., Fairfield, Iowa
Phillips, F.C. Inc., 471 Washington St., Stoughton, Mass.
Phillips Chemical Co., Adams Bldg., Bartlesville, Okla.
Philrus Products Co., 135 Newark St., Newark 4, N.J.
Phoenix Die Casting Co., 21-23 Illinois St., Buffalo 3, N.Y.
Phoenix Mfg. Co., Industry Ave., Joliet, Ill.
Phoenix Products Co., 4715 N 27th St., Milwaukee 9, Wis.
Phoenix Steel Corp., 25 Broad St., New York 4, N.Y.
Picco, Inc., 1729 N Chico Ave., El Monte, Calif.
Pierce, F.O. Co., 2-33 50th Ave., Long Island City 1, N.Y.
Pierce Industries, Inc. of Ohio, S.T.D. Div., 1250 Asbestos Ave., Alliance, Ohio
Pierce & Stevens Chemical Corp., 710 Ohio St., Buffalo, N.Y.
Pioneer Aluminum Inc., 5251 W Imperial Blvd., Los Angeles 45, Calif.
Pioneer Stamped Products Co., P.O. Box 185, Roselawn Sta., Rochester 18, N.Y.
Piper Tool Co., Inc., 15930 Common Rd., Roseville, Mich.
Pittsburgh Corning Corp., 1 Gateway Center, Pittsburgh 22, Pa.
Pittsburgh Die & Casting Co., 7503 Ardmore St., Pittsburgh 18, Pa.
Pittsburgh Forgings Co., 919 Amur St., Jackson, Mich.
Pittsburgh Forgings Co., Thorn St., Coraopolis, Pa.
Pittsburgh Foundry & Machine Co., 36th St., Pittsburgh 1, Pa.
Pittsburgh Plate Glass Co., 632 Ft. Duquesne Blvd., Pittsburgh 22, Pa.
Chemical Div., 1 Gateway Center, Pittsburgh 22, Pa.

In contacting suppliers, please mention the Materials Selector Issue

Fiber Glass Div. (Ad p 313)
1 Gateway Center, Pittsburgh 22, Pa.
Forbes Finishes Div., 3800 W 143rd St., Cleveland, Ohio
Pittsburgh Smelting & Refining Co., 100 W Elizabeth St., Pittsburgh 7, Pa.
Pittsburgh Steel Co., P.O. Box 118, Pittsburgh 19, Pa.
Thomas Strip Div., Grant Bldg., Pittsburgh 30, Pa.
Pittsburgh Steel Foundry Corp., P.O. Box 986, Pittsburgh 30, Pa.
Fort Pitt Steel Casting Div., 25th St., McKeesport, Pa.
Pittsburgh Tool Steel Wire Co., Monaca, Pa.
Pittsburgh Tube Co., 212 Wood St., Pittsburgh 22, Pa.
Plasmadyne Corp., 3839 S Main St., Santa Ana, Calif.
Plast-Ad Mfg. Co., 222 N Michigan St., South Bend 1, Ind.
Plastex Co., 3232 Cleveland Ave., Columbus 24, Ohio
Plastic & Rubber Products Co., 2100 Hyde Pk. Blvd., Los Angeles 47, Calif.
Plastic Engineering, Inc., 8506 Lake Ave., Cleveland 2, Ohio
Plastic Masters, Inc., New Buffalo, Mich.
Plastic Materials, Inc., New South Rd., Hicksville, N.Y.
Plastic Packaging Co., 2035 W Charleston St., Chicago 47, Ill.
Plastic Process Co., Inc., 10400 Aviation Blvd., Los Angeles 45, Calif.
Plastic Products Corp., 24001 Aurora Rd., Bedford Heights, Ohio.
Plastics Engineering Co. (Ad p 222)
1607 Geele Ave., Sheboygan, Wis.
Plastiglide Mfg. Corp., 1757 Stanford St., Santa Monica, Calif.
Pipco International Corp., 1731 Stanford St., Santa Monica, Calif.
Plastic Compounding Corp., 3122 Nebraska Ave., Santa Monica, Calif.
Plax Corp., Box 1019, Hartford, Conn.
Plumb Chemical Corp., 4837 James St., Philadelphia 37, Pa.
Plume & Atwood Mfg. Co., Thomaston, Conn.
Plymouth Cordage Co., Plymouth, Mass.
Plymouth Industrial Products, Inc., 503 Indiana Ave., Sheboygan, Wis.
Pohlman, R.L. Co., 6730 Olive St. Rd., St. Louis 5, Mo.
Pohlman Foundry Co., Inc., 205 Baltz Ave., Buffalo 6, N.Y.
Polacoat, Inc., 9752 Conklin Rd., Cincinnati 42, Ohio
Polar Ware Co., Lakeshore Rd., Sheboygan, Wis.
Pollock, Robert Co., 123 S Maryland Ave., Glendale, Calif.
Polo Plastics Co., 1718 N 1st St., Milwaukee 12, Wis.
Poloron Products, Inc., 165 Huguenot St., New Rochelle, N.Y.
Poly Resins, 11661 Wicks St., Sun Valley, Calif.
Polycast Corp., 69 Southfield Ave., Stamford, Conn.
Polyform Plastics Corp., 24 University Pl., New York 3, N.Y.
Polygon Plastic Co., Walkerton, Ind.
Poly-Kote, Inc., 82 Chestnut St., North Attleboro, Mass.
Polymer Chemical Co., 131 Barron Dr., Cincinnati 15, Ohio
Polymer Corp., 2120 Fairmont Ave., Reading, Pa.
Polymer Corp. of Pennsylvania Sub. (Ad p 264)
2140 Fairmont Ave., Reading, Pa.
Whirlclad Div., 125 N 4th St., Reading, Pa.
Polymer Industries Inc., Springdale, Conn.
Polyphase Machine Co., 43-22 50th St., Woodside 77, N.Y.
Poly Plastic Products, Inc., No. 2 4th Ave., Paterson 4, N.J.
Polytron Corp., 1175 S 10th St., Richmond 4, Calif.
Poor & Co., 80 E Jackson Blvd., Chicago, Ill.
Canton Forge & Axle Works, 2025 Dueber Ave., SW, Canton 6, Ohio
Pope & Talbot, Inc., 3070 NW Front, Portland, Ore.
Porcelain Enamel Finishers, 3221 W 30th St., Chicago 23, Ill.
Porcelain Products, Inc., 225 N Patterson St., Carey, Ohio
Portable Electric Tools, Inc., Admiral Die Castings Div., 250 W 83rd St., Chicago 20, Ill.
Porter, H.K. Inc., 74 Foley, Somerville 43, Mass.
Forge & Fittings Div., 3270 E 79th St., Cleveland 4, Ohio
Porter, H.K. Co., Inc., Alcoa Bldg., Pittsburgh 19, Pa.
Connors Steel Div., 5000 Powell Ave., Birmingham 6, Ala.
National Electric Div., Porter Bldg., Pittsburgh 19, Pa.
Refractories Div., Porter Bldg., Pittsburgh 19, Pa.
Riverside-Alloy Metal Div. (Ad p 150)
1 Pavillion Ave., Riverside, N.J.
Thermoid Div., Tacony & Comly Sts., Philadelphia 24, Pa.
Vulcan-Kidd Steel Div., Aliquippa, Pa.
Porter, William Co., 1007 Santa Fe Ave., Los Angeles 21, Calif.
Portland Co., 58 Fore St., Portland, Me.
Portland Iron Works, 1335 NW Northrup St., Portland 9, Ore.
Posey Iron Works, Inc., 580 S Prince St., Lancaster, Pa.
Potts, C. & G. & Co., 816 Washington Ave., Indianapolis, Ind.
Powder Metals Products Co., 500 St. Marys St., St. Marys, Pa.
Powdercraft Corp., 746 Hayne St., Spartanburg, S. C.
Powell Pressed Steel Co., Hubbard, Ohio
Pratt & Lambert, Inc., 75 Tonawanda St., Buffalo 7, N.Y.
Precision Castparts Corp., 4600 SE Harney Dr., Portland 6, Ore.
Precision Extrusions, Inc. (Ad p 430)
132 S Addison St., Bensenville, Ill.
Precision Founders, Inc., 414 Hester St., San Leandro, Calif.
Precision Machine Co., 1110 E 22nd St., Indianapolis 2, Ind.
Precision Metal Products Co., P.O. Box 129, Ellwood City, Pa.
Precision Metal Spinning Co., 9861 Dixie Hwy., Clarkston, Mich.
Precision Metalsmiths, Inc., 1081 E 200 St., Cleveland 17, Ohio
Precision Paper Tube Co., 2035 W Charleston St., Chicago 47, Ill.
Precision Place Parts, Inc., 712 S Logan St., Mishawaka, Ind.
Precision Plastics Co., 4655 Stenton Ave., Philadelphia 44, Pa.
Precision Rubber Products Corp., 3110 Oakridge Dr., Dayton 7, Ohio
Precision Screw Products Co., Inc., 4764 Valley Blvd., Los Angeles 32, Calif.
Precision Tube Co., Inc., Church Rd. & Wissahickon Ave., North Wales, Pa.
Premier Metal Works, Inc., 1614 S Clinton St., Chicago 16, Ill.
Premier Thermo Plastics Co., Jeffersontown, Ky.
Prescott Co., 1610 15th St., Menominee, Mich.
Presmet Corp., 112 Harding St., Worcester 4, Mass.
Presque Isle Plastics, Inc., 2730 W 12th St., Erie, Pa.
Pressed Steel Co., Wilkes Barre, Pa.
Pressed Steel Tank Co., 1493 S 66th St., Milwaukee 14, Wis.
Pressure Castings, Inc., 21500 St. Clair Ave., Cleveland 19, Ohio
Presswork, Inc., 9100 Roselawn Ave., Detroit 4, Mich.
Prestole Corp., 1345 Miami St., Toledo 5, Ohio
Prince Rubber & Plastics Co., Inc., 1675 Niagara St., Buffalo 7, N.Y.
Production Die Casting Co., P.O. Box 9456, Houston 11, Tex.
Products Research Co., 2919 Empire Ave., Burbank, Calif.
Progressive Service Co., 2745 Locust St., St. Louis 3, Mo.
Protective Treatments, Inc., 420 Dellrose Ave., Dayton 3, Ohio
Puget Sound Plywood, Inc., 230 E. F St., Tacoma 2, Wash.
Purdy, A. R. Co., Inc., Page Ave. & Orient Way, Lyndhurst, N.J.
Pure Carbon Co., Inc. (Ad p 304)
441 Hall Ave., St. Marys, Pa.
Puritan Co., Inc., Beach & Lyell Aves., Rochester, N.Y.
Pusey & Jones Corp., Front & Poplar Sts., Wilmington 9, Del.
Pyramid Industries, Inc., 1422 Irwin Dr., Erie, Pa.
Pyramid Mouldings, Inc., 5353 W Armstrong Ave., Chicago 46, Ill.
Pyramid Plastics, Inc., 556 W Polk St., Chicago 7, Ill.
Pyramid Products Co., Inc., 3967 E 93rd St., Cleveland 5, Ohio
Pyro Plastics Corp., Pyro Park, Union, N.J.
Pyromet Co., 595 Industrial Rd., San Carlos, Calif.
Pyron Corp. (Ad p 430)
Box E, LaSalle Sta., Niagara Falls, N.Y.
Pyrosil, Inc., P.O. Box 206, Cuyahoga Falls, Ohio

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Quaker Alloy Casting Co., Myerstown, Pa.
Quaker City Felt Co., 1734-36 Ludlow St., Philadelphia, Pa.
Quaker State Metals Co., P.O. Box 1167, Lancaster, Pa.
Quality Aluminum Casting Co., 1242 Lincoln Ave., Waukesha, Wis.
Quality Electric Steel Castings, Inc., P.O. Box 9382, Houston 11, Tex.
Queen Products Co., Inc., 13th & Rowan Sts., Louisville 3, Ky.
Quelcor, Inc., Front & Broomall Sts., Chester, Pa.
Quincy Steel Casting Co., 30 Fayette St., North Quincy 71, Mass.
Quinn-Berry Corp., 2609 W 12th St., Erie, Pa.

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REF Mfg. Corp., 391 Jericho Tpk., Mineola, N.Y.
Racine Screw Co., 1501 Clark St., Racine, Wis.
Radiant Color Co., 830 Isabella St., Oakland 7, Calif.
Radiation Applications, Inc., 36-40 37th St., Long Island City 1, N.Y.
Raffi and Swanson, Inc., 100 Eames St., Wilmington, Mass.
Rainier Metal Products Co., 2412 W 71st St., Chicago 29, Ill.
Rand Rubber Co., 397 Sumner Ave., Brooklyn 16, N.Y.
Randolph Products Co., 18 12th St., Carlstadt, N.J.
Rangers Die Casting Co., 10828 S Alameda St., Lynwood, Calif.
Rankin Forge Co., Rankin, Pa.
Rasco-Veeder Co., 1600 S Dearborn St., Chicago 16, Ill.
Rathbone Corp., Park St., Palmer, Mass.
Rausch Mfg. Co., Inc., 750 Pelham Blvd., St. Paul 14, Minn.
Ravenswood Machine Corp., 3325 N Knox Ave., Chicago 41, Ill.
Raybestos-Manhattan, Inc., 61 Willett St., Passaic, N.J.
Adhesives Div. (Ad p 462)
P.O. Box 1021, Bridgeport 2, Conn.
Plastic Products Div. (Ad p 276)
Manheim, Pa.
Raybestos Div., P.O. Box 1021, Bridgeport 2, Conn.
Reinforced Plastics Div. (Ad p 216)
Manheim, Pa.
Rayclad Tubes, Inc., Oakside at Northside, Redwood City, Calif.
Reactive Metals, Inc., 980 Warren Ave., Niles, Ohio
Reade Mfg. Co., Inc., 135 Hoboken Ave., Jersey City 2, N.J.
Reading Tube Corp., Empire State Bldg., 350 5th Ave., New York, N.Y.
Red Devil Mfg. Co., 1405 Ogden Ave., Chicago 10, Ill.
Redmer Air Devices, Box 247, Guntersville, Ala.
Reduction and Refining Co., Kenilworth, N.J.
Reed Plastics Corp., 116 Gold St., Worcester 8, Mass.
Reed & Prince Mfg. Co., 1 Duncan Ave., Worcester 1, Mass.
Reese Metal Products Corp., 537 Howard Ave., Lancaster, Pa.
Reeves Bros., Inc., Vulcan Div. (Ad p 319)
1071 Ave. of Americas, New York, N.Y.
Refinery Castings Co., P.O. Box 5085, Dallas 22, Tex.
Reflin Co., 5660 Kearney Villa Rd., San Diego 11, Calif.
Refractory & Insulation Corp., 120 Wall St., New York 5, N.Y.
Refractory Specialties Co., P. O. Box 108, Norristown, Pa.
Regal Plastic Co., 2800 E 14th St., Kansas City 27, Mo.
Regal Ware, Inc., Kewaskum, Wis.
Reichert Float & Mfg. Co. (Ad p 418)
2242 Smead Ave., Toledo 6, Ohio
Reichhold Chemicals, Inc., 525 N Broadway, White Plains, N.Y.
Alsynite Div., 4654 De Soto St., San Diego, Calif.
Reinhold Engineering & Plastics Co., 12827 E Imperial Hwy., Norwalk, Calif.
Reliable Screw Machine Products, 4433 W Rice St., Chicago 51, Ill.
Reliable Spring & Wire Forms Co., 3167 Fulton Rd., Cleveland 9, Ohio
Reliance Foundry Co., 500-526 E Front St., Cincinnati 2, Ohio
Reliance Plastic & Chemical Corp., 110 Kearney St., Paterson 2, N.J.
Reliance Steel Castings Co., 2818 Smallman St., Pittsburgh 22, Pa.
Remler Co., Ltd., 2101 Bryant St., San Francisco 10, Calif.
Ren Plastics, Inc., 5422 S Cedar Rd., Lansing 17, Mich.
Rensselaer Valve Co., Cohoes, N.Y.
Replac Corp., 2130 St. Clair Ave., Cleveland 17, Ohio
Republic Foil, Inc., 55 Triangle St., Danbury, Conn.
Republic Lead Equipment Co., 7930 Jones Rd., Cleveland 5, Ohio
Republic Metals Co., Inc., 273 Green St., Brooklyn 22, N.Y.
Republic Steel Corp. (Ad pp 86-87)
Republic Bldg., Cleveland 1, Ohio
Steel & Tubes Div., 224 E 131st St., Cleveland 8, Ohio

Republic Supply Co. of Calif., 2600 Eastland Ave., Los Angeles 22, Calif.
Resistoflex Corp., Woodland Rd., Roseland, N.J.
Resolite Corp., P.O. Box 366, Zelienople, Pa.

Revere Copper & Brass, Inc. (Ad p 153)
230 Park Ave., New York 17, N.Y.
Foil Div., 196 Diamond St., Brooklyn 22, N.Y.
Rome Mfg. Div., Mill St., Rome, N.Y.

Rex Products Co., 1910 E 55th St., Cleveland 3, Ohio
Rexall Drug & Chemical Co., Rexall Chemical Co. Div., P. O. Box 37, Paramus, N.J.
Reynolds Aluminum Supply Co., 573 W Peachtree St., NE, Atlanta 3, Ga.
Reynolds Chemical Products Co., 1200 N Main St., Ann Arbor, Mich.
Reynolds Metals Co., P.O. Box 2346-ZA, Richmond, Va.
Foil Div., Reynolds Metals Bldg., Richmond 18, Va.
Rezolin, Inc., 1051 18th St., Santa Monica, Calif.
Rhoads, J.E. & Sons, 2100 W 11th St., Wilmington, Del.

Rhode Island Tool Co. (Ad p 432)
148 W River St., Providence 1, R.I.

Richardson Co., 2737 Lake St., Melrose Park, Ill.
Richmond Foundry & Mfg. Co., Inc., 1300 Hermitage Rd., Richmond 20, Va.
Richmond Mfg. Co., 312 N York St., Houston 3, Tex.
Richmond Mica Corp., 900 Jefferson Ave., Newport News, Va.
Ridge Foundry, 1554 Doolittle Dr., San Leandro, Calif.
Riegel Paper Co., 260 Madison Ave., New York 16, N.Y.
Rigidized Metals Corp., 658 Ohio St., Buffalo 3, N.Y.
Rinshed-Mason Co., Milford at Epworth, Detroit, Mich.
River Smelting & Refining Co., 4195 Bradley Rd., Cleveland 1, Ohio
Riverside Foundry Co., N Front St., Wrightsville, Pa.
Riverside Foundry & Galvanizing Co., 508 Harrison St., Kalamazoo, Mich.
Riverside Plastics Corp., 220 Miller Rd., Hicksville, N.Y.
Roberts Toledo Rubber Co., 4143 Monroe St., Toledo 13, Ohio
Robertson, H.H. Co., 2400 Farmer Bank Bldg., Pittsburgh, Pa.
Robertson Steel & Iron Co., 72 Elm St., Cincinnati 2, Ohio
Robins Products Co., 27027 Groesbeck Hwy., Warren, Mich.
Rochester Novelty Works, Inc., 405 Hague St., Rochester 6, N.Y.
Rockford Bolt & Steel Co., 126 Mill St., Rockford, Ill.
Rockwell Engineering Co., 13500 S Western Ave., Blue Island, Ill.
Rockwell Mfg. Co., LFM Mfg. Co., Inc. Sub., Atchison, Kan.

Rockwell - Standard Corp., Stamping Div. (Ad p 412)
1008 Oswego St., Utica 1, N.Y.

Roddis Plywood Corp., Marshfield, Wis.
Rode, Inc., 85 Green St., Woburn, Mass.
Rodney Hunt Machine Co., 46 Mill St., Orange, Mass.
Rodney Metals, Inc., 1357 Rodney French Blvd., New Bedford, Mass.

Rogers Corp. (Ad pp 270-271)
Rogers, Conn.

Rogers, V.F. Plastic Molding, 4320 Fox St., Denver 16, Colo.
Rohm & Haas Co., Washington Square, Philadelphia 5, Pa.
Rohnco, Inc., P. O. Box 2000, Peoria 5, Ill.
Rohr Aircraft Corp., Foot of "H" St., Chula Vista, Calif.
Rolinco, Inc., 116 Limestone, Bellevue, Peoria 5, Ill.
Roll Coater, Inc., Box 67, Pendleton, Ind.

Roll Formed Products Co. (Ad p 432)
3762 Oakwood Ave., Youngstown, Ohio

Rolle Mfg. Corp., 3rd St. & Cannon Ave., Lansdale, Pa.
Rolled Alloys, Inc., 5309 Concord, Detroit 11, Mich.
Roller Reinforced Plastics, 1303 W 38th St., Box 192, Ashtabula, Ohio
Roleck, Inc., 1358 Kings Hwy., Fairfield, Conn.
Romar Plastics, Inc., 1311 E Main St., St. Charles, Ill.
Rome Strip Steel Co., Inc., 590 Henry St., Rome, N.Y.
Rome Turney Radiator Co., Rome, N.Y.
Rosan, Inc., 2901 W Coast Hwy., Newport Beach, Calif.
Rosco Laboratories, 29 Moore St., Brooklyn 6, N.Y.
Rose Iron Works, 1539 E 43rd St., Cleveland 3, Ohio
Rosedale Foundry & Machine Co., 1731 Preble Ave., Pittsburgh 33, Pa.
Ross & Roberts, Inc., 1299 W Broad St., Stratford, Conn.
Ross-Meehan Foundries, 1601 Carter St., Chattanooga 1, Tenn.
Rostone Corp., Rd. 52 S, Lafayette, Ind.
Roth Rubber Co., 1854 S 54th Ave., Chicago 50, Ill.
Roth Steel Products Co., 1335 E 171st St., Cleveland 10, Ohio
Rotometals, 980 Harrison St., San Francisco 7, Calif.
Rowland Products, Inc., Fairview Lane, Kensington, Conn.
Royce Aluminum Corp., 704 W Water St., Taunton, Mass.
Royston Laboratories, Inc., 1st St., Pittsburgh 38, Pa.
Rubber & Asbestos Corp., 225 Belleville Ave., Bloomfield, N.J.
Rubber Corp. of America, New South Rd., Hicksville, L.I., N.Y.

Rubber Latex Co. of America (Ad p 468)
142 Delawanna Ave., Clifton, N.J.

Rubber & Plastics Compound Co., Inc., 10 Rockefeller Plaza, New York 20, N.Y.
Ruberoid Co., 500 5th Ave., New York 36, N.Y.
Funkhouser Mills Div., P.O. Box 569, Hagerstown, Md.
Ruby Chemical Co., 68-70 McDowell St., Columbus 16, Ohio
Rupert Diecasting Co., 1655 Cleveland Ave., Kansas City 27, Mo.
Russell, Burdsall & Ward Bolt & Nut Co., Midland Ave., Port Chester, N.Y.
Russell Mfg. Co., 400 E Main St., Middletown, Conn.
Russell Reinforced Plastics Corp., 521 W Hoffman Ave., Lindenhurst, N.Y.
Rust-Oleum Corp., 2425 Oakton St., Evanstown, Ill.
Rustproofing & Metal Finishing Corp., 75 Commercial Ave., Cambridge 42, Mass.
Ryerson, Joseph T. & Son, Inc., 16th & Rockwell Sts., Chicago 8, Ill.

S

S & S Mfg. Co., 167 Westcott Dr., Rahway, N.J.
Sager Metal Strip Co., 3649 S Racine, Chicago 9, Ill.
Saginaw Bay Industries, Inc., 242 N Water St., Bay City, Mich.
Saginaw Bearing Co., 821 S Water St., Saginaw, Mich.
St. Clair Rubber Co., 440 E Jefferson Ave., Detroit 26, Mich.
St. Eloi Corp., Box 507, Newtown Station, Cincinnati 44, Ohio

St. Joseph Lead Co. (Ad p 155)
250 Park Ave., New York 17, N.Y.

St. Louis Diecasting Corp., 4528 Oleatha Ave., St. Louis 16, Mo.
St. Louis Malleable Casting Co., 7701 N Conduit Ave., St. Louis, Mo.
St. Louis Steel Casting, Inc., 100 Mott St., St. Louis 15, Mo.
St. Marys Carbon Co., State Rd., St. Marys, Pa.
St. Marys Foundry Co., P.O. Box 248, St. Marys, Ohio
St. Pierre Chain Corp., 50 Frank St., Worcester 4, Mass.
St. Regis Paper Co., 150 E 42nd St., New York, N.Y.
Cambridge-Panelyte Molded Plastics Co. Div., Cambridge, Ohio
Chester Packaging Div., 684 Nepperhan Ave., Yonkers, N.Y.
Panelyte Div. (Ad p 410)
Enterprise Ave., Trenton 8, N.J.

Sall Bros. Co., 2300 Kishwaukee St., Rockford, Ill.
Sall, George Metals Co., Inc., 2255 E Butler St., Philadelphia 37, Pa.
San Francisco Galvanizing Works, 1180 Harrison St., San Francisco 3, Calif.
San Francisco Iron Foundry, 260 Townsend St., San Francisco 7, Calif.

Sandusky Foundry & Machine Co. (Ad p 427)
W Market St., Sandusky, Ohio

Sandvik Steel, Inc. (Ad p 93)
1702 Nevins Rd., Fair Lawn, N.J.

Sandy Hill Iron & Brass Works, 27 Allen St., Hudson Falls, N.Y.
Sanford Plastics Corp., 521 Fifth Ave., New York 17, N.Y.
Sanford Process Co., Inc., 6920 S Central Ave., Los Angeles 1, Calif.
Santay Corp., 351 N Crawford Ave. Chicago 24, Ill.
Saramar Aluminum Co., 4021 Mahoning Ave., Youngstown 1, Ohio
Saran Lined Pipe Co., 2415 Burdette Ave., Ferndale 20, Mich.
Saran Protective Coatings Co., 2415 Burdette Ave., Detroit 20, Mich.
Sargent & Greenleaf, Inc., 24 Seneca Ave., Rochester 21, N.Y.
Sauereisen Cements Co., 1045 N Canal St., Pittsburgh 15, Pa.
Saunders, Alexander & Co., Inc., 195 Bedford St., New York 14, N.Y.
Savannah Machine and Foundry Co., Foundry Div., P. O. Box 2268, Savannah, Ga.
Sawbrook Steel Castings Co., Shepherd & McWhorter Sts., Lockland, Cincinnati 15, Ohio
Sawhill Tubular Products, Inc., P.O. Box 11, Sharon, Pa.

Saxonburg Ceramics, Inc. (Ad p 312)
Box 157, Saxonburg, Pa.

Scaife Co., Anne St., Oakmont, Pa.
Schachner Leather & Belting Co., Charlotte Leather Belting Co. Div., P.O. Box 3205, Charlotte 3, N.C.
Schaefer-Goodnow Foundries, Inc., 2 36th St., Pittsburgh 1, Pa.
Schaefer-Hausner Corp., 527 Lexington Ave., New York 17, N.Y.
Schenectady Varnish Co., Inc., Congress St. & 9th Ave., Schenectady 3, N.Y.
Schilling Bronze Co., 202-216 E North St., Rome 2, N.Y.
Schlegel Mfg. Co., 1555 Jefferson Rd., P. O. Box 197, Rochester 1, N.Y.
Schlueter Mfg. Co., 4616 N Broadway, St. Louis 7, Mo.
Schmeller Aluminum Foundry Co., 3300 E 87th St., Cleveland 27, Ohio
Schneider, Bowman Co., Inc., 1612 Van Dyke St., Philadelphia 24, Pa.
Schrader, J. Co., 4603 Fenwick Ave., Cleveland 1, Ohio
Schramm Fiberglass Products, Inc., 3010 Montrose Ave., Chicago 18, Ill.
Schultz Die Casting Co., 1810 Clinton St., Toledo 7, Ohio
Schumann, I. & Co., 4391 Bradley Rd., P.O. Box 2219, Cleveland 9, Ohio
Schwab Plastics Corp., 17310 Northlawn, Detroit, Mich.
Schwartz Chemical Co., Inc., 50-01 2nd St., Long Island City, N.Y.
Schwarzkopf Development Corp., 595 Madison Ave., New York 22, N.Y.
Scott Paper Co., Foam Div., Eddystone, Pa.
Scottdale Ozone Co., Crescent St., Scottdale, Pa.

Scovill Mfg. Co., Mill Products Div. (Ad p 165)
99 Mill St., Waterbury 20, Conn.

Scranton Plastic Laminating Corp., 3216-18 Pittston Ave., Scranton 5, Pa.
Scudder, E.J. Foundry & Machine Co. Canal & Pearl Sts., Trenton 9, N.J.
Scullin Steel Co., 6700 Manchester Ave., St. Louis 10, Mo.
Seal-Peel, Inc., 755 Stephenson Hwy., Royal Oak 3, Mich.
Sealube Co., 14 Valley St., Wakefield, Mass.
Sealview Plastics, Inc., 1010 Ford St., West Conshohocken, Pa.
Seamless Rubber Co., 253 Hallock Ave., New Haven 3, Conn.
Seaporcel Metals, Inc., 28-20 Borden Ave., Long Island City, N.Y.
Seattle Boiler Works, Inc., 5237 E Marginal Way, Seattle, Wash.
Security Cos., 20096 James Couzens, Detroit 38, Mich.
Security Sash & Screen Co., 385 Midland, Detroit, Mich.
Seiberling Rubber Co., Plastics Div., Newcomerstown, Ohio
Selma Foundry & Machine Co., P.O. Box 662, Selma, Ala.
Sel-Rex Corp., 75 River Rd., Nutley 10, N.J.
Seltzer, George H. & Co., Ridley & B & O RR, P.O. Box 66, Folsom, Pa.
Semon Bache & Co., 636 Greenwich St., New York 14, N.Y.
Seneca Wire & Mfg. Co., Fostoria, Ohio
Sequoia Metalcraft Co., Inc., 1001 Washington St., San Carlos, Calif.
Serrick Corp., Defiance, Ohio
Acme-Lees Div., 1300 Batavia St., Muncie, Ind.
Screw Machine Products Div., 731-22 Perry, Defiance, Ohio
Service Hard Chromium Co., 1012 Greeley Ave., Union, N.J.
Service Steel Co., 1435 Franklin St., Detroit 7, Mich.
Servwell Products Co., 6541 Euclid Ave., Cleveland 3, Ohio
Set Screw & Mfg. Co., 149 Main St., Bartlett, Ill.
Sewell Mfg. Co., 1019 E 10 Mile Rd., Hazel Park, Mich.
Seymour Mfg. Co., 15 Franklin St., Seymour, Conn.
Shakopee Foundry Co., Shakopee, Minn.
Shamban, W.S. & Co., 11617 W Jefferson Blvd., Culver City, Calif.
Shank Metal Products Co., 347 Madison Ave., New York 17, N.Y.
Sharon Steel Corp., Sharon, Pa.
Brainard Steel Div., Griswold St., Warren, Ohio

In contacting suppliers, please mention the Materials Selector Issue

Sharpsville Steel Fabricators, Inc., 6th & Main Sts., Sharpsville, Pa.

Shaw Insulator Co., 160 Colt St., Irvington 11, N.J.

Shawinigan Resins Corp., 644 Monsanto Ave., Springfield 1, Mass.

Shaw-Kendall Engineering Co., 120 S Superior St., P.O. Box 1736, Toledo 3, Ohio

Sheffield Foundry Co., 2070 Clybourn Ave., Chicago 14, Ill.

Sheffield Plastics, Inc., Salisbury Rd., Sheffield, Mass.

Shelby Instrument Co., 1701 Magnolia Ave., Long Beach, Calif.

Shelby Mfg. Co., E Russel Rd., Sidney, Ohio

Sheldon, M.L. & Co., Inc., 350 Lexington Ave., New York 16, N.Y.

Shell Chemical Co., 50 W 50th St., New York 20, N.Y.

Shelier Mfg. Corp., 8-159 General Motors Bldg., Detroit 2, Mich.
Dryden Rubber Div., 1014 S Kildare Ave., Chicago 24, Ill.

Shenango Furnace Co., Centrifugally Cast Products Div., Dover, Ohio

Shenango Refractories, P.O. Box 120, New Castle, Pa.

Sherman & Reilly, Inc., 1st & Broad Sts., Chattanooga, Tenn.

Sherritt Gordon Mines, Ltd., 2910, 25 King St. W, Toronto, Ontario, Canada

Sherwatt Equipment & Mfg. Co., Inc., 47 Murray St., New York 7, N.Y.

Sherwin-Williams Co., 101 Prospect Ave., NW, Cleveland 1, Ohio

Shieldalloy Corp., West Blvd., New Field, N.J.

Shingle, L. H. Co., 356 Franklin St., Worcester 4, Mass.

Shingle Leather Co., 1300 Walnut St., Camden 3, N.J.

Shriver, T. & Co., Inc., 890 Hamilton St., Harrison, N.J.

Shull Bros. Glass Co., 509 N 6th St., Millville, N.J.

Shur-Lok Corp., 879 S East St., Anaheim, Calif.

Sibley Machine & Foundry Corp., 206 E Tutt St., South Bend 23, Ind.

Sierra Electric Corp., 15100 S Figueroa St., Gardena, Calif.

Sierra Engineering Co., 123 E Montecito, Sierra Madre, Calif.

Sierracin Corp., 903 N Victory Blvd., Burbank, Calif.

Sifco Metachemical, Inc., 935 E 63rd St., Cleveland 3, Ohio

Sillcocks Miller Co., 10 W Parker Ave., Maplewood, N.J.

Simmons Fastener Corp. (Ad p 463)
N Broadway, Albany 1, N.Y.

Simon Products Co., 3211 W Grand St., Chicago 51, Ill.

Simonds Saw and Steel Co., 470 Main St., Fitchburg, Mass.

Simoniz Co., Simoniz Products Div., 11512 W King St., Franklin Park, Ill.

Simonsen Metal Products Co., 4444 W Chicago, Chicago 51, Ill.

Simpson Timber Co., 1010 White Bldg., Seattle, Wash.

Sinclair Co., 60 Appleton St., Holyoke, Mass.

Sinko Mfg. & Tool Co., 7310 W Wilson Ave., Chicago 31, Ill.

Sintered Metals, Inc., 3390 Washington St., Jamaica Plain 30, Mass.

Sioux City Foundry & Boiler Co., E 8th & Division Sts., Sioux City 2, Iowa

Sipe Metals Corp., 1720 N Elston Ave., Chicago 22, Ill.

Sivyer Steel Casting Co., 43rd & Mitchell Ave., Milwaukee 14, Wis.

Skookum Co., Inc., 8504 W Crawford St., Portland 3, Ore.

Skyline Industries, Titusville 1, Pa.

Small Tube Products, Inc., P. O. Box 1032, Altoona, Pa.

Smith, A.O. Corp., 3533 N 27th St., Milwaukee 1, Wis.

Smith, A.P. Mfg. Co., 500 N Arlington Ave., East Orange, N.J.

Smith, N.J. Bolt Co., P.O. Box 7398, Houston 8, Tex.

Smith Chemical & Color Co., Inc., 55 John St., Brooklyn 1, N.Y.

Smith & Winchester Mfg. Co., South Windham, Conn.

Smith-Armstrong Forge, Inc., 1209 Marquette Rd., Cleveland 14, Ohio

Smithers Tool & Machine Products, Inc., 64 S Broadway, Red Hook, N.Y.

Smith-Moon Steel Co., Inc., Courier Bldg., Winfield, Kan.

Smith-Victor Corp., Griffith, Ind.

Smoot-Holman Co., 321 N Eucalyptus Ave., Inglewood, Calif.

Snyder Mfg. Co., Inc., 1458 5th St. NW, New Philadelphia, Ohio

Snyder, M.L. & Son, Inc., Jasper & York Sts., Philadelphia 15, Pa.

Solar Aircraft Co., 2200 Pacific Hwy., San Diego 12, Calif.

Solar Steel Corp., Union Commerce Bldg., Cleveland, Ohio

Solon Foundry, Inc., 6370 SOM Center Rd., Solon, Ohio

Somers Brass Co., Inc. (Ad p 158)
94 Baldwin Ave., Waterbury 20, Conn.

Somerset Foundry & Machine Co., 809-831 Edgewood Ave., Somerset, Pa.

Sommer Metalcraft Corp., 315 Poston Dr., Crawfordsville, Ind.

Sonken-Galamba Corp., 2nd & Riverview, Kansas City 18, Kan.

Sorbo-Cast Corp., New Brunswick, N.J.

Sorbo-Mat Process Engineers, 106 S Hanley St., St. Louis 5, Mo.

South Chester Corp., Southco Div., Lester, Pa.

South River Metal Products Co., Inc., 377 Turnpike, South River, N.J.

Southern Adhesives Corp., 1501 W Moore St., Richmond, Va.

Southern Aluminum Finishing Co., Inc., 1581 Huber St., NW, Atlanta 18, Ga.

Southern Asbestos Co., 1000 Seaboard Rd., Charlotte, N.C.

Southern Belting & Transmission Co., P.O. Box 4296, Atlanta 2, Ga.

Southern Car & Mfg. Co., Inc., 1831 29th Ave. N, Birmingham, Ala.

Southern Electric, Inc., Designers Metals Div., 8701 S Greenwood Ave., Chicago 19, Ill.

Southern Extrusions, Inc., N Washington St., Magnolia, Ark.

Southern Fabricating Co., Inc., 818 20th St., Sheffield, Ala.

Southern Galvanizing Co., 1620 Bush St., Baltimore 30, Md.

Southern Metal Products Co., 4444 N Miro St., New Orleans 17, La.

Southern Plastics Co., 408 Pendelton St., Columbia, S.C.

Southern Screw Co., P.O. Box 1360, Statesville, N.C.

Southwestern Plastic Pipe Co., P.O. Box 117, Mineral Wells, Tex.

Southwestern Porcelain Steel Corp., P.O. Box 607, Sand Springs, Okla.

Spaulding Fibre Co., Inc. (Ad p 277)
310 Wheeler St., Tonawanda, N.Y.

Special Screw Products Co., 100 Northfield Rd., Bedford, Ohio

Specialty Resins Co., 2801 Lynwood Rd., Lynwood, Calif.

Speer Carbon Co. (Ad p 316)
St. Marys, Pa.

Spencer Chemical Co., Dwight Bldg., 1004 Baltimore Ave., Kansas City 5, Mo.

Spencer Nahm Co., 765 1st Ave., San Leandro, Calif.

Spencer Rubber Co., Main & Chapel Sts., Manchester, Conn.

Spencer's Sons, I.S. Inc., 20 Fair St., Guilford, Conn.

Sperry Rubber & Plastics Co., 31 W 7th St., Brookville, Ind.

Spincraft, Inc., 4122 W State St., Milwaukee 8, Wis.

Spiral-Glas Pipe Co., P.O. Box 1951, Old Bridge, N.J.

Spraylat Corp. (Ad p 355)
1 Park Ave., New York 16, N.Y.

Spring City Foundry Co., Hall & Main Sts., Spring City, Pa.

Spring Packing Corp., 332 S Michigan Ave., Chicago 4, Ill.

Spriegel's Foundry Co., Inc., 201 S 1st St., Terre Haute, Ind.

Springfield Foundry Co., 295 Pasco Rd., Indian Orchard, Mass.

Spruce Pine Mica Co., Inc., P.O. Box 456, Spruce Pine, N.C.

Spuck Iron & Foundry Co., 3145 N 14th St., St. Louis 7, Mo.

Stacey Mfg. Co., Township Ave., & Big Four RR, Cincinnati 16, Ohio

Stackpole Carbon Co., St. Marys, Pa.

Stainless Foundry & Engineering, Inc., 5132 N 35th St., Milwaukee 9, Wis.

Stainless Metals, Inc., 19-42 42nd St., Long Island City 1, N.Y.

Stalker Corp., 203 Woodside Ave., Essexville, Mich.

Stalwart Rubber Co., 160 Northfield Rd., Bedford, Ohio

Stamford Metal Specialty Co., Inc., 429 W Broadway, New York 12, N.Y.

Stamford Rolling Mills Co., Inc., Springdale, Conn.

Standard Asbestos Mfg. Co., 860 W Evergreen Ave., Chicago 22, Ill.

Standard Casting Corp., 4400 W Cermak Rd., Chicago 23, Ill.

Standard Felt Co., 29-115 S Palm Ave., Alhambra, Calif.

Standard Forge & Axle Co., Inc., P.O. Box 309, Montgomery 1, Ala.

Standard Foundry Co., Southgate & Armory Sts., Worcester 10, Mass.

Standard Insulation Co., Plastics Div., 74 Paterson Ave., East Rutherford, N.J.

Standard Locknut & Lockwasher Inc., 2250-56 Valley Ave., Indianapolis 18, Ind.

Standard Magnesium Corp., 7500 E 41st St., Tulsa, Okla.

Standard Metals Corp., 262 Broad St., North Attleboro, Mass.

Standard Nut & Bolt Co., Abbott St., Valley Falls, R.I.

Standard Packaging Corp., Johnston Foil Div., 6106 S Broadway, St. Louis 11, Mo.

Standard Plastics Co., 62 Water St., Attleboro, Mass.

Standard Pressed Steel Co., Box 808, Jenkintown, Pa.

Standard Products Co., 316 Fisher Bldg., Detroit, Mich.

Standard Screw Co., Wilson, Conn.
Chicago Screw Co. Div., 2701 Washington Blvd., Bellwood, Ill.
Hartford Machine Screw Co. Div., P.O. Box 1440, Hartford 2, Conn.
Western Automatic Machine Screw Co. Div., 377 Woodland Ave., Elyria, Ohio

Standard Screw Products Co., 506 S Palm Ave., Alhambra, Calif.

Standard Stamping & Perforating Co., 3129 W 49th Place, Chicago 32, Ill.

Standard Steel Sections, Inc., 608 E 133rd St., New York, N.Y.

Standard Tube Co., 24400 Plymouth Rd., Detroit 39, Mich.

Standard Washer & Mat, Inc., 155 Adams St., Manchester, Conn.

Stanley Chemical Co., Berlin St., East Berlin, Conn.

Stanley Works, Stanley Industrial Sales Div., 195 Lake St., New Britain, Conn.

Stanwood Corp., 4819 Cortland, Chicago 39, Ill.

Star Expansion Industries Corp., Pleasant Hill Rd., Mountainville, N.J.

Star Heel Plate Co., Inc., 12 Thornton St., Newark 5, N.J.

Star Porcelain Co., Muirhead Ave., Trenton, N.J.

Star Stainless Screw Co., 194 Union Ave., Totowa, N.J.

Star Stamping Co., 1303 M-139, Benton Harbor, Mich.

Star Wire Screen & Iron Works Inc., 2515 San Fernando Rd., Los Angeles 65, Calif.

Star Woolen Co., Cohoes, N.Y.

State Foundry & Machine Co., Cedar Grove, Wis.

Stauffer Chemical Co., 380 Madison Ave., New York 17, N.Y.
Molded Products Div., 3211-15 E 26th St., Los Angeles 23, Calif.

Staver Co., Inc., 49 N Saxon Ave., Bay Shore, N.Y.

Stearns-Roger Mfg. Co., P.O. Box 5370, Denver 17, Colo.

Steel Fabricators Co., 1252-B Spruce St., Cleveland 13, Ohio

Steel Heddle Mfg. Co., 2100 Allegheny Ave., Philadelphia 32, Pa.

Steel Improvement and Forge Co., 970 E 64th St., Cleveland, Ohio

Steel Industries, Inc., 907 Louise Ave., Crawfordsville, Ind.

Steel Protection & Chemical Co., Mooresville, Ind.

Steel Shot Producers, Inc., 4389 Harrison St., Pittsburgh 1, Pa.

Steel, R. & Sons, Inc., 42-21 9th St., Long Island City 1, N.Y.

Steelcote Mfg. Co., 3418 Gratiot St., St. Louis 3, Mo.

Steere Enterprises, Inc. (Ad p 351)
422 S Broadway, Akron 8, Ohio

Steinen, William Mfg. Co., 43 Bruen St., Newark 5, N.J.

Stella Products Corp., 66 Okner Pky., Livingston, N.J.

Stenman, Bror F., West St., Auburn, Mass.

Sterling Alderfer Co., 3050 Granger Rd., Akron 13, Ohio

Sterling Aluminum Products, Inc., 2600 N 3rd St., St. Charles, Mo.

Sterling Bolt Co., 363 W Erie St., Chicago 6, Ill.

Sterling Brass Foundry, Inc., 1640 Sterling Ave., Elkhart, Ind.

Sterling Die Casting Co., 743 39th St., Brooklyn 32, N.Y.

Sterling Foundry Co., 8 Wallace St., Sterling, Ill.

Sterling Models, Belfield & Wister Sts., Philadelphia 44, Pa.

Sterling Molders, Inc., 277 Military Rd., Buffalo 7, N.Y.

Sterrit-Thomas Foundry Co., 32nd & Smallman St., Pittsburgh 1, Pa.

Stevens, Frederic B., Inc., 1800 18th St., Detroit, Mich.

Stevens, J.P. & Co., Inc., 1460 Broadway, New York 36, N.Y.

Steward, D.M. Mfg. Co., E 36th St., Chattanooga, Tenn.

Stewart-Warner Corp., Stewart Die Casting Div., 4535 W Fullerton Ave., Chicago 39, Ill.

Stillman Rubber Co. (Ad p 415)
5811 Marilyn Ave., Culver City, Calif.

Stillman White Foundry Co., Inc., 42 Dodge St., Providence, R.I.

Stimpson, Edwin B. Co., Inc., 70 Franklin Ave., Brooklyn 5, N.Y.

Stirrup Metal Products Corp., 215 Emmet St., Newark 5, N.J.

Stockwell Rubber Co., Inc., 1117 Shackamaxon St., Philadelphia 25, Pa.

Stone Straw Corp., Stone Paper Tube Div., 900 Franklin St., NE, Washington 17, D.C.

Stoody Co., Whittier, Calif.

Stover Co., 100 S Hancock Ave., Freeport, Ill.

Stowe-Woodward, Inc., 181 Oak St., Newton 64, Mass.
Straahan Foil Co., Inc., 100 Wesley St., South Hackensack, N.J.
Strick Plastics Co., Perkasie, Pa.
Strong Steel Foundry Co., 33 Norris St., Buffalo 7, N.Y.
Structural Fibers, Inc., 5th Ave., Chardon, Ohio
Struthers Wells Corp., 30 Rockefeller Plaza, New York 20, N.Y.
Stuart Foundry Co., 138 S Junction St., Detroit 9, Mich.
Studebaker - Packard Corp., Gering Plastics Div., N 7th St. & Monroe Ave., Kenilworth, N.J.
Stulz-Sickles Co., 929-939 Julia St., Elizabeth, N.J.
Subax, Inc., Fairmount Plant, Hackensack, N.J.
Sun Chemical Corp., 10th St. & 44th Ave., Long Island City 1, N.Y.
Electro Technical Div., 113 E Centre St., Nutley 10, N.J.
Sun Rubber Co., 366 Fairview Ave., Barberton, Ohio
Sun Steel Co., Special Products Div., 1700 W 74th Pl., Chicago 36, Ill.
Sun Tube Corp., 181 Long Ave., Hillside, N.J.
Sunlite Plastics, Inc., 1506 W Pierce St., Milwaukee, Wis.
Superb Light Alloys, Inc., Allen Blvd., Farmingdale, N.Y.
Superior Carbon Products, Inc., 9115 George Ave., Cleveland 5, Ohio
Superior Die Casting Co., 1001 London Rd., Cleveland 10, Ohio
Superior Drawn Steel Co., Beaver Ave., Monaca, Pa.
Superior Foundry, Inc., 3542 E 71st St., Cleveland 5, Ohio
Superior Industries, Inc., 3786 Oakwood Ave., Youngstown 9, Ohio
Superior Mfg. Co., 13th & Rockland Sts., Philadelphia 41, Pa.
Superior Plastics, Inc., 426 N Oakley Blvd., Chicago 12, Ill.
Superior Plating, Inc., University & 1st Ave. NE, Minneapolis 13, Minn.
Superior Spinning & Stamping Co., 4057-63 Fitch Rd., Toledo 13, Ohio
Superior Steel Corp., Carnegie, Pa.
Superior Steel & Malleable Castings Co., Benton Harbor, Mich.
Superior Tube Co. (Ad pp 424-425)
Box 191, Norristown, Pa.
Superior-Pacific Galvanizing Co., 1711 E 61st St., Los Angeles 1, Calif.
Supreme Industrial Products Co., 367 N Karlov Ave., Chicago 24, Ill.
Surprenant Mfg. Co., 199 Washington St., Boston 8, Mass.
Swan Rubber Co., 436 E Mansfield St., Bucyrus, Ohio
Swayne-Robinson & Co., 210 Main St., Richmond, Ind.
Swedish Crucible Steel Co., 8801 Conant Ave., Detroit 11, Mich.
Swedlow, Inc., 6986 Bandini Blvd., Los Angeles, Calif.
Kevinite Div., 394 N Meridian Rd., Youngstown 9, Ohio
Swepco Tube Corp., 1 Clifton Blvd., Clifton, N.J.
Swett, A.L. Iron Works, 172 Glenwood Ave., Medina, N.Y.
Swift & Co., Adhesive Products Dept., 4115 Packers Ave., Chicago 9, Ill.
Switzer Bros., Inc., 4732 St. Clair Ave., Cleveland 3, Ohio
Sylvan Plastics Inc., 1617 Pennsylvania Ave., Philadelphia 3, Pa.
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N.Y.
Chemical & Metallurgical Div., Towanda, Pa.
Parts Div., Warren, Pa.
Sylvester & Co., 17706 Miles Ave., Cleveland 28, Ohio
Symington Wayne Corp., Symington Div., Depew, N.Y.
Synco Resins, Inc., Henry St., Bethel, Conn.
Synthane Corp., River Oaks, Pa.

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Tallman-McCluskey Fabrics Co., 236 E Monroe, Kirkwood 22, Mo.
Tanner Engineering Co., 1003 Santa Fe Ave., Los Angeles 21, Calif.
Taylor & Co., Inc., 680 Morgan Ave., Brooklyn 22, N.Y.
Taylor & Boggis Foundry, 1290 E 53rd St., Cleveland, Ohio
Taylor & Fenn Co., 22 Deerfield Rd., Windsor, Conn.
Taylor Fibre Co. (Ad p 265)
Box 471, Norristown, Pa.
Taylor Forge & Pipe Works, P.O. Box 485, Chicago 90, Ill.
Techalloy Co., Inc., Rte. 113, Rahns 5, Pa.
Technic, Inc., 88 Spectacle St., Cranston, R.I.
Technical Ply-Woods Sales, 6756 Crandon Ave., Chicago 49, Ill.
Technical Specialties Co., 415 Concord Ave., New York 55, N.Y.
Technical Tape Corp., 240 North Ave., New Rochelle, N.Y.
Teimer, Roland Co., Inc., 134 Tremont St., Everett 49, Mass.
Temco, Inc., 4101 Charlotte Ave., Nashville, Tenn.
Temescal Metallurgical Corp. (Ad p 167)
2850 7th St., Berkley, Calif.
Tempil Corp., 132 W 22nd St., New York 11, N.Y.
Terre Haute Bronze & Brass Foundry, 1114 Sycamore St., Terre Haute, Ind.
Terre Haute Malleable & Mfg. Corp., 2030 N 19th St., Terre Haute, Ind.
Testor Chemical Co., 600 Buckbee, Rockford, Ill.
Texas Aluminum Co., Inc., 512 Mercantile Securities Bldg., Dallas, Tex.
Texas Foundries, Inc., P.O. Box 180, Lufkin, Tex.
Texas Glass Fiber Corp., 147 Island Grove Rd., Grandview, Tex.
Texas Instruments, Inc., Metals & Controls Div. (Ad p 366)
34 Forest St., Attleboro, Mass.
Texas Steel Co., 3901 Hemphill St., Fort Worth 9, Tex.
Texas-U.S. Chemical Co., P.O. Box 667, Port Neches, Tex.
Texstar Corp., Texstar Plastics Div., 1400 Henderson, Fort Worth 1, Tex.
Textile Shield Co., Inc., 1 Groton St., Lawrence, Mass.
Textron, Inc., 50 S Main, Providence, R.I.
Campbell, Wyant & Cannon Foundry Co. Div., Henry St., Muskegon, Mich.
Textron Metals Co., 39 James St., Girard, Ohio
Thalco, 765 S Harvard Blvd., Los Angeles, Calif.
Thatcher Glass Mfg. Co., Inc., McKee Div., Bullitt Ave., Jeannette, Pa.
Thermal American Fused Quartz Co., 15-19 Salem St., Dover, N.J.
Thermal Refractories Corp., 4501 Dell Ave., North Bergen, N.J.
Thermon Mfg. Co., 1017 Rosine St., Houston, Tex.
Thinsheet Metals Co., 271-TR Railroad Hill St., Waterbury 20, Conn.
Thiokol Chemical Corp., 780 N Clinton Ave., Trenton 7, N.J.
Thombert, Inc., 316 E 7th St., N, Newton, Iowa
Thompson and Co., 1085 Allegheny Ave., Oakmont, Pa.
Thompson, H. I. Fiber Glass Co., 1733 Cordova St., Los Angeles 7, Calif.
Thompson Industries, Inc., Manhasset, N.Y.
Thompson Pipe & Steel Co., 3001 Larimer St., P.O. Box 2852, Denver 1, Colo.
Thompson Products, Inc., 23555 Euclid Ave., Cleveland 17, Ohio
Light Metals Div., 2269 Ashland Rd., Cleveland, Ohio
Kolcast Industries Div., P.O. Box 250, Minerva, Ohio
Valve Div., 1455 E 185th St., Cleveland 10, Ohio
Thompson, K.W. Tool Co., 20 Dexton Ave., New Hyde Park, N.Y.
Thompson Wire Co., 41 Mildred Ave., Boston 26, Mass.
Thompson-Bremer & Co., 228 N La Salle St., Chicago 1, Ill.
Thomson, Judson L. Mfg. Co., Sawyer Rd., Waltham, Mass.
Thys Co., 6900 Folsom Blvd., Sacramento 19, Calif.
Tiarco Corp., Box 766, Clark, N.J.
Tickle, Arthur Engineering Works, Inc., 21 Delevan St., Brooklyn 31, N.Y.
Al-Fin Div., 21 Delevan St., Brooklyn 31, N.Y.
Timber Products Co., P.O. Box 1032, Medford, Ore.
Timken Roller Bearing Co., Steel & Tube Div., 1835 Dueber Ave., SW Canton 6, Ohio
Tingley Rubber Corp., 903 Ross St., Rahway, N.J.
Tinnerman Products, Inc., Dept. 16, P.O. Box 6688, Cleveland 1, Ohio
Titanium Metals Corp. of America, 233 Broadway, New York 7, N.Y.
Titchener, E. H. & Co., 67 Clinton St., Binghamton, N.Y.
Toepfer & Sons, Inc., 6667 N Teutonia Ave., Milwaukee 9, Wis.
Toledo Industrial Rubber Co., 2238 Smead Ave., Toledo 6, Ohio
Toledo Stamping & Mfg. Co., 99 Fearing Blvd., Toledo 7, Ohio
Tompkins Products, 1040 W Grand Blvd., Detroit 8, Mich.
Tool & Mfg. Co., Inc., P.O. Box 10344, Pittsburgh 34, Pa.
Topeka Foundry & Iron Works Co., Inc., 300-324 Jackson St., Topeka, Kan.
Torngren, C.W. Co., Inc., 236 Pearl St., Somerville 45, Mass.
Torrington Co., 59 Field St., Torrington, Conn.
Tousey Varnish Co., 520 W 25th St., Chicago 16, Ill.
Tower Grove Foundry, 4438 Hunt Ave., St. Louis 10, Mo.
Townsend Co., Engineered Fasteners Div., P.O. Box 71, Ellwood City, Pa.
Toyad Corp., Plant Blvd., Latrobe, Pa.
Trane Co., 206 Cameron Ave., La-Crosse, Wis.
Transition Metals & Chemicals, Inc., U.S. Magnesium Div., Wallkill, N.Y.
Transue & Williams Steel Forging Corp., 562 W Ely St., Alliance, Ohio
Trent Tube Co., P.O. Box 88, Pittsburgh 30, Pa.
Trenton Brass Co., 621 Prospect St., Trenton, N.J.
Trenton Pipe Nipple Co., P.O. Box 1234, Trenton 7, N.J.
Triangle Conduit & Cable Co., Inc., P.O. Box 711, New Brunswick, N.J.
Triangle Stamping Co., 5101 Carnegie Ave., Cleveland 3, Ohio
Trigon Specialties Corp., 1005 S Lafayette Blvd., South Bend 18, Ind.
Trim Alloys, Inc., 30-40 W 3rd St., Boston 27, Mass.
Tri-Point Plastics, Inc., 175 I. U. Willets Rd., Albertson, L.I., N.Y.
Tri-State Plastic Molding Co., 505 4th St., Henderson, Ky.
Trojan Steel Co., P.O. Box 2426, Charleston 29, W. Va.
Trostel, Albert Packings, Ltd., Lake Geneva, Wis.
Troy Blanket Mills (Ad p 317)
200 Madison Ave., New York, N.Y.
Truche Leather Co., Peabody, Mass.
True Alloys, Inc., 284 S Summit St., Detroit 9, Mich.
Tube Distributors Co., Inc., 1415 Kellum Pl., Garden City, N.Y.
Tube Methods, Inc., Depot & Rambo Sts., Bridgeport, Pa.
Tube Reducing Corp., 520 Main Ave., Wallington, N.J.
Tube Turns Plastics, Inc., 2929 Magazine St., Louisville 11, Ky.
Tubular Rivet & Stud Co., Weston Ave., Quincy 70, Mass.
Tuff Clad, Inc., W Oak St. Extension, Kent, Ohio
Turco Products, Inc., 6135 S. Central Ave., Los Angeles 1, Calif.
Turner Halsey Co., 40 Worth St., New York 13, N.Y.
Turner & Seymour Mfg. Co., Lawton St., Torrington, Conn.
Twin City Die Castings Co., Talmadge & 33rd Aves., SE, Minneapolis 14, Minn.
Twitchell, E. W., Inc., 2806 N 3rd St., Philadelphia 33, Pa.
Tyer Rubber Co., Andover, Mass.
Tyler, W.S. Co., 3615 Superior Ave., Cleveland 14, Ohio

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UBS Chemical Corp., 491 Main St., Cambridge 43, Mass.
Uddeholm Co. of America, Inc., 155 E 44th St., New York 17, N.Y.
Udylite Corp., 1651 Grand Blvd., Detroit 11, Mich.
Ulbrich Stainless Steels Corp., Old Colony Rd., Wallingford, Conn.
Ullmann, Inc., 4305 N 127th St., Butler, Wis.
Uniform Tubes, Inc., Collegeville 2, Pa.
Union Asbestos & Rubber Co., 1111 W Perry St., Bloomington, Ill.
Union Carbide Corp., 270 Park Ave., New York 17, N.Y.
Haynes Stellite Co. Div., 270 Park Ave., New York 17, N.Y.
Linde Co. Div. (Ad p 349)
270 Park Ave., New York 17, N.Y.
National Carbon Co. Div. (Ad p 306)
270 Park Ave., New York 17, N.Y.
Silicones Div. (Ad p 275)
270 Park Ave., New York 17, N.Y.
Union Carbide Chemicals Co. Div., Textile Fibers Dept., 270 Park Ave., New York 17, N.Y.
Union Carbide Metals Co. Div., 270 Park Ave., New York 17, N.Y.
Union Carbide Plastics Co. Div. (Ad p 261)
270 Park Ave., New York 17, N.Y.
Vinyl Foam Div., 796 Frelinghuysen Ave., Newark, N.J.
Visking Co. Div., 6733 W 65th St., Chicago 38, Ill.
Union Chemical Corp., 410 Frelinghuysen Ave., Newark 5, N.J.
Union Forging Co., 500 North St., Endicott, N.Y.
Union Iron Works, P.O. Box 2135, Spokane, Wash.
Union Paste Co., 1605 Hyde Park Ave., Hyde Park 36, Mass.
Union Screw & Mfg. Co., Box 25, Imperial, Pa.
Union Spring & Mfg. Co., 2nd Ave. & 8th St., New Kensington, Pa.

In contacting suppliers, please mention the Materials Selector Issue

Union Steel Corp., Stanley Terrace, Union, N.J.
Union Tank Car Co., 228 N LaSalle, Chicago, Ill.
Graver Tank & Mfg. Co. Div., 4809 Tod Ave., East Chicago, Ind.
Unique Wire Weaving Co., Inc., 276 Ramset Ave., Hillside, N.J.
Unitcast Corp., Water Works Dr., Toledo 9, Ohio
United Carbon Products Co., 1310 N Madison St., Bay City, Mich.
United Cork Cos., 15 Central Ave., Kearney, N.J.
United Forge Co., 277 Dubois, Detroit 7, Mich.
United International Research, Inc., 38-15 30th St., Long Island City 1, N.Y.
United Metal Products Corp., 8101 Lyndon Ave., Detroit 38, Mich.
United Mineral & Chemical Corp., 16 Hudson St., New York 13, N.Y.
United Refining & Smelting Co., 2920 W Carroll Ave., Chicago 12, Ill.
United Rubber & Chemical Co., P.O. Box 149, Baytown, Tex.
United Screw & Bolt Corp., 2513 W Cullerton Ave., Chicago 8, Ill.

United Shoe Machinery Corp. (Ad p 465)
140 Federal St., Boston 7, Mass.

United Sintered Alloys, St. James, L.I., N.Y.
United Smelting & Aluminum Co., Inc., P.O. Box 1910, New Haven 9, Conn.
U.S. Bronze Powders, Inc., Flemington, N.J.

U.S. Ceramic Tile Co., Sparta Mfg. Co. (Ad p 400)
Dover, Ohio

U.S. Challenge & Challenge Co., 1441 N Kingsburg St., Chicago 22, Ill.
U.S. Extrusions Corp., 120 Old Broadway, Garden City Park, N.Y.
U.S. Flexible Tubing Co., Bartlett, Ill.
U.S. Gasket & Shim Co., 2743 2nd St., Cuyahoga Falls, Ohio
U.S. Gypsum Co., 300 W Adams St., Chicago 6, Ill.
U.S. Magnet & Alloy Corp., 266 Glenwood Ave., Bloomfield, N.J.
U.S. Metal Products Co., P.O. Box 1067, Erie, Pa.
U.S. Mica Co., Inc., 1525 Circle Ave., Forest Park, Ill.
U.S. Pipe and Foundry Co., 3300 1st Ave. N, Birmingham 3, Ala.
U.S. Plywood Corp., 55 W 44th St., New York 36, N.Y.
U.S. Polymeric Chemicals, Inc., Box 546, Stamford, Conn.
U. S. Reduction Co., Chicago Ave. & Melville St., East Chicago, Ind.
U. S. Rubber Co., 1230 Ave. of the Americas, New York 20, N.Y.
Kem-Blo Dept., Naugatuck, Conn.
Naugatuck Chemical Div., Elm St., Naugatuck, Conn.
Royalite Plastic Products Div., 2638 Pulaski Rd., Chicago 39, Ill.
Textile Div., 1230 Ave. of the Americas, New York 20, N.Y.
U. S. Smelting, Refining & Mining Co., 62 William St., New York, N.Y.
U.S. Steel Corp., 525 William Penn Pl., Pittsburgh 30, Pa.

American Steel & Wire Div. (Ad pp 90-91)
Rockefeller Bldg., Cleveland 13, Ohio

Columbia-Geneva Steel Div., 120 Montgomery St., San Francisco 6, Calif.
National Tube Div., 525 William Penn Pl., Pittsburgh 30, Pa.
Tennessee Coal and Iron Div., P.O. Box 599, Fairfield, Ala.
United States Steel Supply Div., 208 S La Salle St., Chicago 4,
U. S. Stoneware Co., P.O. Box 350, Akron 9, Ohio
Alite Div., P.O. Box 119, Orrville, Ohio

Colonial Rubber Co. Div. (Ad p 416)
706 Oakwood St., Ravenna, Ohio

Conneaut Rubber & Plastics Co. Div. (Ad p 413)
P.O. Box 621, Conneaut, Ohio

U.S. Valve & Mfg. Co., 256 E Grand Ave., South San Francisco, Calif.
United Wire & Supply Corp., 1497 Elmwood Ave., Providence 7, R.I.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.
New England Tape Co. Div., 30 Tower St., Hudson, Mass.
Palnut Co. Div., 16 Glen Rd., Mountainside, N.J.
Unity Machine & Tool Corp., 2727 E Westmoreland St., Philadelphia 34, Pa.
Universal Castings Corp., 5621 W 66th St., Chicago 38, Ill.
Universal Converting Corp., 1125 County St., New Bedford, Mass.
Universal Screw Co., 2401 Brummel Place, Evanston, Ill.
Universal Unlimited, Inc., Pratt Oval, Glen Cove, N.Y.
Universal-Cyclops Steel Corp., Bridgeville, Pa.
Empire-Reeves Steel Div., Bridgeville, Pa.
University of Tennessee, Dept of Chemistry, University Sta., Knoxville 16, Tenn.
Uniworld Research Corp. of America, 9802 Euclid Ave., Cleveland 6, Ohio
Upson Co., Stevens St., Lockport, N.Y.
Urrite Plastics Fabricators, 4740-2 S Durfee Rd., Pico-Rivera, Calif.
Utica Drop Forge & Tool Co., 2409-15 Whitesboro St., Utica 4, N.Y.
Utica General Jobbing Foundry, Inc., 1801 Foundry St., Utica 3, N.Y.
Utica Radiator Corp., Dwyer Ave., Utica, N.Y.
Utility Mfg. Co., 2443 Boston Rd., North Wilbraham, Mass.
Utility Steel Foundry, 3320 E Slauson, Vernon, Calif.

V

Vacuum Technology, Inc., 7933 Gloria Ave., Van Nuys, Calif.
Valley Iron Works, 81 E Water St., St. Paul 7, Minn.
Valley Metallurgical Processing Co., Plasmatech Div., Essex, Conn.
Valley Steel Casting Co., Foot of 11th St., Bay City, Mich.
Valley-National Corp., Clark St., Milldale, Conn.
Vanadium Corp. of America, 420 Lexington Ave., New York 17, N.Y.

Vanadium-Alloys Steel Co. (Ad p 88)
Latrobe, Pa.

Anchor Drawn Steel Co., Latrobe, Pa.
Colonial Steel Div., Monaca, Pa.
Metal Forming Corp. Div., 1937 Sterling Ave., Elkart, Ind.
Vanamatic Co., 204 S Jefferson St., Delphos, Ohio
Van der Horst Corp., Olean, N.Y.
Van Dorn Iron Works Co., Colonial Plastics Div., 2685 E 79th St., Cleveland 4, Ohio
Van Huffell Tube Corp., Larchmont Ave., NE, Warren, Ohio
Van Pelt Corp., Service Steel Div., Box 532, Detroit 32, Mich.
Van Valkenburg, L.D. Co., Box 190, Holyoke, Mass.
Varcum Chemical Corp., P.O. Box 476, Niagara Falls, N.Y.
Varflex Corp., 512 W Court St., Rome, N.Y.
Variety Stamping Corp., 12695 Elmwood Ave., Cleveland 11, Ohio
Vascoloy-Ramet Corp., 800 Market St., Waukegan, Ill.
Veeder-Root Inc., 70 Sargeant St., Hartford 2, Conn.
Vellumoid Co., 54 Rockdale St., Worcester 6, Mass.
Velcro Sales Corp., 681 5th Ave., New York 22, N.Y.
Veremere, E.A. Inc., 11623 S Broadway, Los Angeles 61, Calif.
Victor Equipment Co., 844 Folsom St., San Francisco 7, Calif.
Victor Mfg. & Gasket Co., 5750 W Roosevelt Rd., Chicago 50, Ill.
Victor Steel Products Corp., 1175 Leggett Ave., New York 59, N.Y.
Victory Plastics Co., 81 Apsley St., Hudson, Mass.
Viking Copper Tube Co., 16700 St. Clair Ave., Cleveland, Ohio
Viking Pump Co., 4th & Rubendahl Sts., Cedar Falls 1, Iowa
Viplax Products Corp., 408 E Warren St., Beverly, N.J.
Vitro Chemical Co., 342 Madison Ave., New York 17, N.Y.
Vogt Mfg. Corp., 100 Fernwood Ave., Rochester, N.Y.
Volco Brass & Copper Co., Kenilworth, N.J.
Volkert Stampings, Inc., 222-34 96th Ave., Queens Village 29, N.Y.
Vollrath Co., Contract Div., 1236 N 18th St., Sheboygan, Wis.
Vulcan Foundry Co., Oakland, Calif.
Vulcan Iron Works, 730 S Main St., Wilkes Barre, Pa.
Vulcan Mfg. Co., Box 22, Cincinnati 15, Ohio
Vulcan Metal Products, Inc., 2801 6th Ave., S, Birmingham, Ala.
Vulcan Rail & Construction Co., 59-30 54th St., Maspeth, N.Y.
Vulcanized Rubber & Plastics Co., 5 S Pennsylvania Ave., Morrisville, Pa.

W

W. F. Mfg. Co., 1509 Gardena Ave., Glendale 4, Calif.
WLS Stamping Co., 3292 E 80th St., Cleveland 4, Ohio
Wabash Metal Products Co., Inc., P.O. Box 298, Wabash, Ind.
Wagner Malleable Iron Co., 1275 E Sangamon, Decatur, Ill.
Wagner, E.R. Mfg. Co., 4611 N 32nd St., Milwaukee 9, Wis.
Wagner Plastic Corp., Rte. 88, Lakewood, N.J.
Wagner Specialty Co., 647 Dodge St., Burlington, Wis.

Wah Chang Corp. (Ad p 152)
233 Broadway, New York 7, N.Y.

Walmet Alloys Co., 1999 Guoin St., Detroit 7, Mich.
Wakefield Bearing Corp., 45 Foundry St., Wakefield, Mass.
Waldes Kohinoor, Inc., 47-16 Austel Pl., Long Island City 1, N.Y.

Waldman, Jos. & Sons, Epoxy Products Div. (Ad p 460)
137 Colt St., Irvington, N.J.

Walker Forge, Inc., 2000 17th St., Racine, Wis.

Wall Colmonoy Corp., (Ad p 498)
19345 John R. St., Detroit 3, Mich.

Wall, P. Mfg. Co., Erie St., Grove City, Pa.
Wall Tube & Metal Products Co., P.O. Box 330, Newport, Tenn.
Wallingford Steel Co., 80 Valley St., Wallingford, Conn.
Wal-Mar Corp., 2800 Bernice Rd., Lansing, Ill.
Walrod Machine Products, 5225 SE 7th Ave., Portland 2, Ore.
Waltham Foundry Co., 71 Felton St., Waltham 54, Mass.
Walton Gibb Leather Co., Inc., 54th & Grays Ave., Philadelphia 43, Pa.
Ward, H.H. Co., 4th & Engle Sts., Chester, Pa.
Warner Mfg. Corp., 265 Watsessing Ave., Bloomfield, N.J.
Warren Bros. Roads Co., 32 Potter St., Cambridge 42, Mass.
Warren Plastics & Engineering, Inc., 2120 E Nine Mile Road, Warren, Mich.
Wasco Products, Inc., 5 Bay State Rd., Cambridge 38, Mass.
Washburn Wire Co., Phillipsdale Div., Bourne Ave., Phillipsdale, R.I.
Washington Iron Works, 1500 6th Ave., S, Seattle 4, Wash.
Washington Mfg. Co., Inc., P.O. Box 370, Washington, Iowa
Washington Steel Corp., Washington, Pa.
Waterbury Buckle Co., 952 S Main St., Waterbury 20, Conn.
Waterbury Cos., Inc., P.O. Box 1032, Waterbury, Conn.
Waterbury Pressed Metal Co., 300 Chase Ave., Waterbury 14, Conn.
Waterbury Rolling Mills, Inc., Box 550, Waterbury 20, Conn.
Waterman Industries, Inc., 515 S. G St., Exeter, Calif.
Watertown Mfg. Co., Echo Lake Rd., Watertown, Conn.
Watson-Standard Co., 225 Galveston Ave., Pittsburgh 12, Pa.

Waukesha Foundry Co. (Ad p 401)
Lincoln Ave., Waukesha, Wis.

Wayne Agricultural Works, Inc., Goldsboro, N.C.
Wayne Chemical Products Co., 9470 Copland Ave., Detroit 17, Mich.
Wayne Foundry & Stamping Co., 3100 Hubbard St., Detroit 10, Mich.
Weatherhead Co., 128 W Washington Blvd., Fort Wayne 1, Ind.
Weber-Knapp Co., 441 Chandler St., Jamestown, N.Y.
Webster Mfg., Inc., 1100 W Davis St., Tiffin, Ohio
Weckesser Co., Inc., 5701 Northwest Hwy., Chicago 46, Ill.
Wedler Bros., Inc., 1535 E 38th St., Cleveland 14, Ohio
Weiskittel, Harry C. Co., Inc., 4901 Pulaski Hwy., Baltimore 24, Md.
Welding Apparatus Co., 2750 W Van Buren St., Chicago 12, Ill.
Wellington Sears Co., 111 W 40th St., New York 18, N.Y.
Wellman, S.K. Co., 20 Egbert Rd., Bedford, Ohio
Wellman Bronze and Aluminum Co., 9401 Woodland Ave., Cleveland 4, Ohio
Wells, A.H. & Co., Inc., 100 E Aurora St., Waterbury, Conn.
Wells Aluminum Corp., 50 Henry St., North Liberty, Ind.
Wellsville Fire Brick Co., Wellsville, Mo.
Werner, R.D. Co., Inc., P.O. Box 580, Greenville, Pa.
Werner Foundry & Machine Co., 8th St. & Reading R.R., Lansdale, Pa.
Wesbar Stamping Corp., West Bend, Wis.
Wesco Spring Co., 4501 S Knox Ave., Chicago 32, Ill.
Wessels Co., 1625 E Euclid Ave., Detroit 11, Mich.
West Haven Foundry Co., 27 Kimberly Ave., West Haven, Conn.
West Irving Die Casting Co., 240 S Evergreen St., Bensenville, Ill.
West Steel Casting Co., 1679 Coffamer Rd., Cleveland 10, Ohio
West Virginia Malleable Iron Co., Point Pleasant, W. Va.
West Virginia Pulp & Paper Co., 230 Park Ave., New York 17, N.Y.
Western Automatic Machine Screw Co., 377 Woodland Ave., Elyria, Ohio
Western Backing Corp., 3512 Helms Ave., Culver City, Calif.
Western Coating Co., Box 598, Oakridge Sta., Royal Oak 3, Mich.

Addresses of Suppliers

Western Felt Works (Ad p 310)
4115 W Ogden Ave., Chicago 23, Ill.
Acadia Synthetic Products Div., 4115 Ogden Ave., Chicago 23, Ill.

Western Foundry & Machine Works, Inc., 201 Jefferson St., Topeka, Kan.

Western Iron & Foundry Co., Inc., 702 E 2nd St., Wichita 2, Kan.

Western Machine Co., 180 W Holt Ave., Milwaukee 7, Wis.

Western Plastics Corp., 1515 W 2nd St., Hastings, Neb.

Western Plastics Corp., 3110 Ruston Way, Tacoma 2, Wash.

Western Textile Products Co., 2131 Hickory St., St. Louis 4, Mo.

Western Tool & Die Works, 421 NW 3rd Ave., Portland 9, Ore.

Westinghouse Electric Corp., 101 Liberty Ave., Gateway Center, Pittsburgh, Pa.
Materials Mfg. Dept., Box 128, Blairsville, Pa.
Micarta Div. (Ad pp 239-246)
Hampton, S.C.

Westlake Plastics Co., 145 W Lenni Rd., Lenni Mills, Pa.

Westland Die Casting, Inc., 714 Roberta St., Glendale 1, Calif.

Westlectric Castings, Inc., 2040 S Camfield Ave., Los Angeles 22, Calif.

Westmoreland Malleable Iron Co., Westmoreland, N.Y.

Weyerhaeuser Timber Co., Silvatek Products Div., Tacoma Bldg., Tacoma 1, Wash.

Wheatland Tube Co., Bankers Securities Bldg., Philadelphia 7, Pa.

Wheaton Die Casting Corp., N 10th St., Millville, N.J.

Wheeler, C.H. Mfg. Co., Wheelerweld Div., Ambler, Pa.

Wheeling Corrugating Co., Wheeling, W. Va.

Wheeling Steel Corp. (Ad pp 84-85)
1134-40 Market St., Wheeling, W. Va.

Wheelock, Lovejoy & Co., Inc., 128 Sidney St., Cambridge 39, Mass.

Wheland Co., 27th & Broad Sts., Chattanooga 20, Tenn.

Whitaker Metals Corp., 1301 Burlington St., North Kansas City 16, Mo.

White Metal Rolling & Stamping Corp., 80 Moultrie St., Brooklyn 22, N.Y.

White Sewing Machine Corp., Apex Reinforced Plastics Div., Elm & Washington Sts., Cleveland 13, Ohio

Whitehead Metal Products Co., Inc., 303 W 10th St., New York 14, N.Y.

Whitfield Chemical Co., 14225 Schaefer Hwy., Detroit 27, Mich.

Whitso, Inc., 9330 Byron St., Schiller Park, Ill.

Whyte, Oliver Co., Inc., 115 4th Ave., New York 3, N.Y.

Wickes Corp., U. S. Graphite Co. Div., 1621 Holland Ave., Saginaw, Mich.

Wickwire Bros., Inc., 189 Main St., Cortland, N.Y.

Wilcox Forging Corp., Chestnut & Allen Sts., Mechanicsburg, Pa.

Wildberg Bros. Smelting & Refining Co., P.O. Box 468, South San Francisco 2, Calif.

Wilde Drop Forge & Tool Co., Inc., 2938 Fairmount Ave., Kansas City 8, Mo.

Wilde Tool Co., Inc., 13th & Pottawatomie St., Hiawatha, Kan.

Wilder Mfg. Co., Inc., 1143 Terven Ave., Salinas, Calif.

Willamette Iron and Steel Co., 2800 NW Front Ave., Portland 10, Ore.

Williams, A.C. Co., Ravenna, Ohio

Williams, F.B. Co., 507 E Pershing Rd., Chicago 53, Ill.

Williams, J.H. & Co., 400 Vulcan St., Buffalo 7, N.Y.

Williams Gold Refining Co., Inc., 2978 Main St., Buffalo 14, N.Y.

Williams, H.E. Products Co., 106 S Main St., Carthage, Mo.

Williams, E.A. & Son, 325 Washington Ave., Carlstadt, N.J.

Williams-Bowman Rubber Co. (Ad p 422)
1949 S 54th Ave., Cicero 50, Ill.

Williamson Adhesives, Inc., 8220 Kimball Ave., Skokie, Ill.

Wilmad Glass Co., Inc., Rt. 40 & Oak Rd., Buena, N.J.

Wilmington Fibre Specialty Co., New Castle, Del.

Wilson Steel & Wire Co., 4840 S Western Ave., Chicago 9, Ill.

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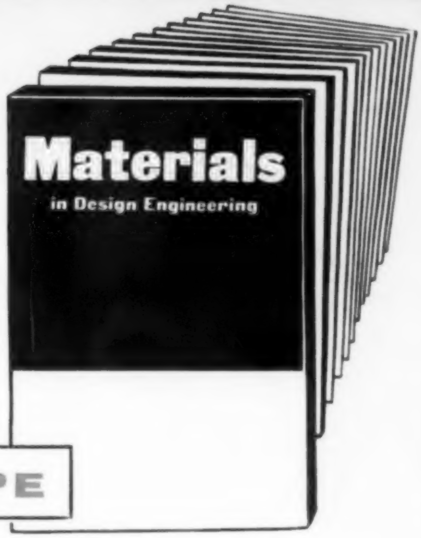

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Here are the five basic groups of engineering materials, forms, and finishes used in product design and manufacture. They are specified by M/DE subscribers and readers. The editorial content of M/DE is devoted exclusively to the selection and use of these materials:

1 IRONS & STEELS

for example –

Carbon steels
Alloy steels
Stainless steels
Tool steels
Heat resistant alloys
Gray, malleable, nodular irons

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2 NONFERROUS METALS

for example –

Aluminum
Copper, brass, bronze
Magnesium
Zinc, lead, tin
Nickel
Titanium
Zirconium
Low melting alloys
Noble metals
Rare metals
Cemented carbides

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3 NONMETALLIC MATERIALS

for example –

Plastics
Rubbers
Silicones
Vulcanized fibres
Impregnated materials
Wood-base materials
Ceramics
Refractories
Glasses and fiberglass
Carbon and graphite
Industrial felts, fabrics and fibers
Leather
Paper-base materials

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4 FORMS & SHAPES

for example –

Sand castings
Die castings
Permanent mold castings
Precision castings
Centrifugal castings
Shell mold castings
Drop and press forgings
Stampings
Headed products
Weldments
Brazed assemblies
Metal powder parts
Extrusions
Spinnings
Wire and wire parts
Screw machine products
Drawn and roll formed parts
Tubing and tubular parts
Molded nonmetallics
Formed nonmetallics

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5 FINISHES & COATINGS

for example –

Plated coatings
Clad surfaces
Galvanized, tinned metals
Hard facings
Paints, synthetics, enamels
Anodized finishes
Phosphate coatings
Rustproofing
Chemical coloring
Sprayed metal coatings
Porcelain enamels
Ceramic coatings
Plastic and rubber coatings
Mechanical finishes

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